BROOKHAVEN NATIONAL LABORATORY

INSTITUTIONAL PLAN
FY 1997 --- FY 2002

October 1996

ASSOCIATED UNIVERSITIES, INC.
UPTON, NEW YORK 11973-5000

Brookhaven National Laboratory

Institutional Plan · 1997 - 2001

October 1996

PRELIMINARY DATA FOR INSTITUTIONAL PLAN FY 1995 --- FY 2000

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I. LABORATORY DIRECTOR'S STATEMENT

As a research laboratory, Brookhaven is ever alert to new ideas and new ways to pursue them. Our forward-looking approach to forefront science is deeply rooted in an old BNL tradition: providing researchers who come to use the Laboratory's facilities with the very best tools for their work.

We call those researchers our "users," and the tools we provide them are our "user facilities." Since Brookhaven National Laboratory was founded in 1947, these facilities have been unique, innovative and, above all, of great use to the community of scientists from academia, industry and other laboratories who flock here year-round to take advantage of them.

The expertise that led to our facility with facilities began developing at BNL almost as soon as the Laboratory opened its doors and work began on the first two "big machines" - the Brookhaven Graphite Research Reactor (BGRR) and the Cosmotron.

As advanced as those facilities were for their time, further pioneering designs by BNL teams led to their obsolescence: With the discovery of strong focusing, the Cosmotron gave way to the 10 times more -energetic Alternating Gradient Synchrotron (AGS). The BGRR was supplanted by the High Flux Beam Reactor (HFBR), which came on line almost 30 years ago with facility design innovations yielding more neutrons for researchers.

While our mix of facilities is constantly changing as new ones are built, older ones upgraded and ones that have passed their prime decommissioned, we have concentrated on building machines that are organic in nature: fully capable of being improved in response to our staff's interaction with the user community.

A wonderful example of this is the AGS, where three experiments have captured Nobel Prizes in Physics for our users. I was an AGS user when it started accelerating protons in July 1960, and its design intensity was already impressive. We would have been amazed then to know that by April 1995, the AGS would again break its own world record for proton intensity, with 63.3 trillion protons per pulse - 6,300 times greater than its original design intensity!

Similar improvements mark the shorter history of our National Synchrotron Light Source (NSLS). Over the last 14 years, huge leaps have been made in its design parameters for flux, brightness, current and size of the electron beam. And the user community's approval is shown in their ever-increasing numbers - now, more than 2,600 researchers use the Light Source annually.

Now, our staff's ingenuity is critical to the Relativistic Heavy Ion Collider (RHIC), which will be Brookhaven's next major user facility. By cleverly designing a tunnel to link the heavy ion-producing Tandem Van de Graaff with the AGS, the two workhorse accelerators became the key to injecting heavy ions into RHIC; the 1991 addition of the Booster to this accelerator chain enhanced the number masses of ion species that the AGS can deliver to RHIC.

Beyond RHIC, we are exploring several new facility options for the Laboratory. These include a possible pulsed-neutron source, a "next-generation" light source in which a free electron laser would produce deep ultraviolet light, and a muon collider, which would provide highly energetic particle reactions at a much lower cost and in a much smaller facility than any other existing or proposed accelerator.

The Brookhaven staff has always been able to come up with unique approaches to our facilities because they are more than designers- they are users too. In fact, as a result of peer-review competition, BNL researchers end up using these facilities about 20 percent of the time- a nice balance with the outside user community.

Keeping one's balance means keeping things in focus- but sometimes refocusing is in order. That's what Brookhaven is doing now in response to intensive reviews of the missions and efficiency of the national laboratories. So, while we believe our missions have always melded nicely with the U.S. Department of Energy's core activities, we are also concentrating on enhancing our specific strengths even further. In addition to the "big machines" I've already discussed, these include:

- ***Structural biology*** - BNL can be a pillar of great strength in this field, with our renowned Protein Data Bank, which provides Internet users with a database of three-dimensional structures of biological macromolecules; our expertise in structural determination at the HFBR and NSLS; and our command of the increasingly important area of genome sequencing.

- ***Brookhaven Center for Imaging and Neurosciences***- We have dedicated a new, high-field magnetic resonance imaging (MRI) facility, which will be one of the center's three parts, along with our existing facilities for positron emission tomography, or PET, and single photon emission computed tomography, known as SPECT.

- ***Center for Radiation Chemistry Research***- Another new user facility about to be launched is the Pulse Radiolysis Facility (PRF), which radiation chemists will use as a high-tech stopwatch to examine the dynamics of chemical species that live only a few trillionths of a second. In this new center, the PRF will augment and be 1,000 times faster than our 45-year-old, two-million-electron-volt Van de Graaff accelerator.

- ***Radiotherapy for cancer*** - When clinical trials in boron neutron capture therapy got under way at our Medical Research Reactor in February, people desperately ill with the brain cancer glioblastoma multiforme were given a chance to help advance therapies for this invariably fatal illness and, perhaps, gain relief of their own. BNCT adds another dimension to cancer therapy at Brookhaven, where the Radiation Therapy Facility run by the University Medical Center at Stony Brook offers outpatient treatment to cancer sufferers.

- ***Applied areas*** - Our researchers continue to look at better ways of treating the environment, handling wastes and restoring the nation's infrastructure. This year, for example, our scientists developed an encapsulation process for sealing radioactive, hazardous and mixed wastes in plastic for safe disposal and became part of a four-year pilot demonstration program aimed at cleaning up pollution in the New York-New Jersey Harbor.

As we refocus, we must also expand our focus to include not just the nation but the entire planet. It's a global world now, and, reflecting that, Brookhaven has forged research agreements with many other countries. Most recently, we signed a pact with the Japanese laboratory RIKEN ensuring that, with their $20 million contribution, spin physics research will be conducted at RHIC.

Another example of global cooperation is FACE- our free-air carbon-dioxide enrichment program for evaluating the effect of atomospheric carbon on plants' rate of photosynthesis. This critical environmental technology is being used in locations ranging from Arizona to New Zealand.

And, of course, I'm looking forward to our working with the Large Hadron Collider now being built at CERN, which we consider our sister laboratory in Europe. BNL physicists are gearing up to make major contributions to both the detectors and aspects of the accelerator magnet program.

In addition to refocusing our scientific priorities, we have also been reviewing the way we do business: Due to tightening national budgets, we must become more efficient in our science and adopt best business practices in our operations.

Toward this end, we have had many introspective reviews of our operations, and this has led us from refocusing and reviewing to reengineering of the Brookhaven's base- its people. While we have had to downsize over the past year, we have tried to do that as humanely as possible, mainly through voluntary layoffs. We also realize that our major resource and the vitality of the Laboratory- is the quality of our people.

So, despite the funding restraints, it is our highest priority to maintain an environment conducive to making good people want to work here, and to continue to encourage creativity, innovation and ingenuity among our staff.

The stable environment necessary for these attributes to flourish was given a big boost this year when DOE awarded our Associated Universities, Inc. (AUI), management team another five-year contract.

AUI reflects our interaction and commitment to academia and industry. With this relationship continuing, with our unique mix of facilities and other scientific endeavors, and with a strong core of talented people, I believe that we are well-positioned to meet the challenges that lie ahead.

II. MISSIONS AND CORE COMPETENCIES

Our Laboratory's mission is based upon supporting the basic Department of Energy activities. We were founded as a laboratory which would provide specialized research facilities that could not be de-signed, built and operated at a university or industrial complex, and this still remains a basic mission of the Laboratory. Brookhaven's four core missions are described below.

MAJOR CORE MISSIONS

RESEARCH FACILITIES

Expertise to conceive, design, build and operate complex leading-edge, user-oriented research facilities in a safe and environmentally responsible manner.

SCIENTIFIC RESEARCH

Expertise to carry out basic and applied scientific research in long-term, high-risk programs. This is an essential capability needed to keep our research facilities at the cutting-edge of science. These programs lead to new insights and technological advances which provide the underlying scientific base supporting DOE missions and generating long-term benefits to the nation.

TECHNOLOGY DEVELOPMENT

Expertise to develop advanced technologies that address national needs, support and strengthen the ability of DOE to carry out its missions, support other federal and state agencies, and enable industry to benefit from the multidisciplinary research and development at the Laboratory.

KNOWLEDGE TRANSFER

Expertise and mechanisms for disseminating scientific and technical knowledge to educate new generations of scientists and engineers, to produce a technically trained work force, to enhance scientific literacy of the general public. In addition, by directly interacting with U.S. industry, we contribute to improving the competitiveness of our industrial complex.

These missions are interrelated in a complex manner and are not independent isolated competencies. Research Facilities and Scientific Research have a synergistic relationship. Each area must have a significant staff of excellent stature. To maintain and constantly push to improve the performance and productivity of a research facility, it is essential that the two staffs interact directly on all aspects of

the effort. That interaction will drive the performance of the complex. Having the several complementary facilities at one location, such as the National Synchrotron Light Source and the High Flux Beam Reactor, allows a unique research capability such as in material science and biological structure determination. Our other two core missions, Technology Development and Knowledge Transfer, cut across all of the research facilities and research programs.

In each of these mission areas we have a set of core competencies which are described in the fol-lowing pages. These core competencies support and cut across the four central activities of the Depart-ment of Energy, as defined in its Strategic Plan, playing a major role in the Science and Technology, the Environmental Quality, and the Energy Resources sectors, with a smaller but special role in the National Security arena and also support the derivative activities of the Department Industrial Competitiveness.

In order to better see the connection between the various Brookhaven activities that form our core competencies and the Department of Energy core activities we label each broad competency with the following letter code describing the match.

SCI	Science and Technology
ENV	Environmental Quality
ENER	Energy Resources
SEC	National Security

At the end of this section we present a matrix showing the correlation between DOE's major business areas and the sections within each of our Laboratory's core competencies.

MAJOR ACTIVITY CLUSTERS
RESEARCH FACILITIES

LARGE FACILITIES

ALTERNATING GRADIENT SYNCHROTRON (SCI)

- Research in Particle and Nuclear Physics
- High-Intensity Frontier of Particle Physics
- World's Only High Energy Polarized Proton Source
- At Present, Nation's Only High Energy, Heavy Ion Synchrotron
- Over 800 Users

RELATIVISTIC HEAVY ION COLLIDER (under construction) (SCI)

- Dedicated Colliding Beams Facility for Ultra Relativistic Collisions of Heavy Nuclei
- Highest Priority Construction Project for U.S. Nuclear Physics
- New Phases of Nuclear Matter at the High-Temperature Frontier
- Large and Unique High Energy Physics Potential (e.g., spin physics)
- International Community of Over 800 Scientists

HIGH FLUX BEAM REACTOR (SCI, ENER, ENV)

- 16 Instruments for Research in Condensed-Matter Physics, Biology, Chemistry, Applied Sciences and Industrial Applications
- Facilities for Radio-Isotope Production and Radiation Damage Studies
- 270 users

NATIONAL SYNCHROTRON LIGHT SOURCE (SCI, ENV, ENER)

- Two Storage Rings Providing Intense UV and X-ray Photon Sources
- 83 Beamlines for Research in Materials Science, Biology, Chemistry, Medical and Industrial Applications
- R&D on Free Electron Lasers and on Production and Utilization of Synchrotron Radiation
- Over 2300 Users, Including 400 Industrial Users

BIOMEDICAL FACILITIES

BROOKHAVEN CENTER FOR IMAGING AND NEUROSCIENCE (SCI)

- Positron Emission Tomography (PET), Single Photon Emission Computed Tomography (SPECT), and High-Field (4 Tesla) Magnetic Resonance Imaging (MRI) for Research in the Basic and Clinical Neuroscience (Substance Abuse; Aging; Brain Cancer; Drug Research) and the Development of New Forms of Imaging

BROOKHAVEN LINEAR ISOTOPE PRODUCTION FACILITY (SCI)

- Production of Isotopes for Medical Purposes
- Approximately 20 Isotopes Produced for Commercial and/or Research Use

MEDICAL RADIATION FACILITY (SCI)

- Cancer Patient Treatment: 250 patients annually

BROOKHAVEN MEDICAL RESEARCH REACTOR (SCI)

- Neutron Capture Cancer Therapy Research

SCANNING TRANSMISSION ELECTRON MICROSCOPE (SCI)

- Structural Biology, Molecular Masses
- Over 75 Users

PROTEIN DATA BANK (SCI)

- World-Wide Repository for ThreeDimensional Structures of Biological Macromolecules

GENOME SEQUENCING CENTER(under development) (SCI)

- Large-Scale DNA Sequencing

OTHER FACILITIES

TANDEM VAN DE GRAAFF FACILITY (SCI, SEC, ENV, ENER)

- Injector (source) for Heavy Ions for AGS/RHIC
- Microchip Radiation Testing Facility
- Film Irradiation Plant for Track Etching Filter Membranes
- 250 Industrial Users from 45 Institutions

ACCELERATOR TEST FACILITY (SCI, SEC)

- Advanced Acceleration Concepts

CENTER FOR RADIATION CHEMISTRY RESEARCH (SCI, ENER, ENV)

- Study of Rapid Chemical Reactions: Catalysis, Energy Conversion and Storage

NATIONAL NUCLEAR DATA CENTER (SCI, SEC, ENV)

- Nuclear Cross-Section and Structure Data
- 1100 Users

BOOSTER APPLICATIONS FACILITY (under development) (SCI, SEC)

- Proton and Heavy Ion Radiobiology & Microelectronics Radiation Effects

DYNAMITRON ACCELERATOR

- 3 Mev electron or positron accelerator (SCI)
- Device calibration

MAJOR ACTIVITY CLUSTERS
SCIENTIFIC RESEARCH

HIGH ENERGY PARTICLE AND NUCLEAR PHYSICS (SCI)

- Beyond the Standard Model
  - Rare Kaon Decays
  - Muon Anomalous Magnetic Moment
  - Exotics and Glueball Spectroscopy
  - Strange Matter
  - Solar Neutrinos
- Relativistic Heavy Ions
  - Nuclear Matter in Extreme States of Temperature and Density
  - QCP Phase Transitions: hadrons to Quark-Gluon Plasma
  - Recreate Conditions of the Early Universe, Microseconds after the Big Bang

ADVANCED ACCELERATOR CONCEPTS (SCI, SEC)

- Short Wavelength Accelerating Structures
- Production of Coherent Radiation Free Electron Laser
- Muon Collider
- Neutron Sources

MATERIALS SCIENCES (SCI, ENER)

- Magnetism and Superconductivity
- Surface Studies - Catalysis, Corrosion, and Adhesion
- Condensed Matter Theory: Metallic Alloys and Cooperative Phenomena
- Materials Characterization with Neutron and X-Ray Scattering
- Defect Structure with Positrons

CHEMICAL SCIENCES (SCI, ENER, ENV)

- Dynamics and Energetics and Reaction Kinetics
- Thermal, Photo- and Radiation-Induced Reactions
- Catalysis
- Porphyrin Chemistry
- Electrochemistry

ENVIRONMENTAL SCIENCES (SCI, ENV)

- Global Change
- Atmospheric Chemistry
- Oceanography
- Soil Chemistry
- Cycling of Pollutants
- Environmental Remediation

MEDICAL SCIENCE (SCI)

- Medical Imaging: PET, SPECT, MRI, Coronary Angiography
- Nuclear Medicine
- Radionuclides, Radiopharmaceuticals, Synthesis and Applications

- Advanced Cancer Therapies: Neutron Capture, Microbeam Radiation, Proton Radiation, Photon Activation Therapy (PAT)
- Mechanisms of Oncogenesis

MOLECULAR BIOLOGY AND BIOTECHNOLOGY (SCI)

- Genome Structure, Gene Expression
- DNA Damage and Repair
- Molecular Genetics
- Plant Science
- Bio-Structure Determination by X-ray and Neutron Scattering
- Enzyme Kinetics by Laue Crystallography
- Mass Measurements by Electron Microscopy

ADVANCED SCIENTIFIC COMPUTING AND SYSTEMS ANALYSIS (SCI, ENV, ENER)

- Risk Assessment
- Energy Modeling
- Groundwater Modeling
- Traffic Congestion Simulation
- Atmospheric Transport Modelling

MAJOR ACTIVITY CLUSTERS
TECHNOLOGY DEVELOPMENT

PHYSICAL, CHEMICAL AND MATERIALS SCIENCE (SCI, ENER, SEC)

- State-of-the-Art Instrumentation and Devices for Precision Electronics, Optics and Microelectronics
- Superconducting and Magnetic Materials
- X-ray Lithography
- Micromachining
- Battery Technology
- Permanent Magnets
- "Designer" Polymers
- Flat Planar Optic Displays

ACCELERATOR TECHNOLOGY (SCI, SEC)

- High-Field, High-Quality Superconducting Magnets
- High-Power Radio Frequency Systems
- Ultrahigh Vacuum Systems
- Advanced Accelerator Designs
  - High-Gradient Acceleration
  - High-Beam Current Acceleration
  - Novel Structures for Synchrotron Radiation Generation, FELs
- Accelerator/Spallation Source Applications
- Insertion Device Development: Wigglers and Undulators

ENVIRONMENTAL AND CONSERVATION TECHNOLOGIES (SCI, ENV, ENER, SEC)

- Environmental Remediation and Mitigation
- Energy-Efficiency Technologies
- Waste Treatment
- Disposal of Nuclear Materials
- Radiation Protection
- Infrastructure Modernization
- Transportation: Intelligent Vehicle Highway System, MAGLEV
- Ultra Sensitive Detection and Characterization

MEDICAL TECHNOLOGIES (SCI)

- Biomedical Applications of Nuclear Technology
- Production of Radionuclides/Radiopharmaceuticals
- Development of Particle Radiation Therapies for Cancer
- Medical Imaging
- X-ray Microbeam Therapy

BIOTECHNOLOGY (SCI)

- Neutron and Synchrotron X-ray Scattering
- Large-Scale Genome Sequencing
- High-Resolution Scanning and Cryo Electron Microscopy
- Cloning, Expressing and Engineering Genes
- Metal Cluster Compounds for Electron Microscope Labels
- Phage Displays for Probing Specific Interactions

SAFETY SAFEGUARDS AND RISK ASSESSMENT (SEC, SCI, ENV, ENER)

- Safeguards, Nonproliferation and Arms Control
- Safety Analysis of Complex Systems
- Probabilistic Risk Assessment and Management
- Human Reliability
- Material and Component Survivability Testing
- Remote Sensing of Chemical Signatures
- Technical Support for U.S. Policy

MAJOR ACTIVITY CLUSTERS
KNOWLEDGE TRANSFER

EDUCATING FUTURE GENERATIONS OF SCIENTISTS AND ENGINEERS
(SCI, ENV, ENER, SEC)

- Scientific Publishing, Lecturing, Conference Participation
- Visiting Scientist Program
- Accelerator Fellowship Program
- Postdoctoral Research Associates
- Engineering Intern Program
- Graduate Student Thesis Projects
- Adjunct Teaching Appointments at Local Colleges
- Office of Educational Programs
  Precollege and College Programs for Students and Teachers

EDUCATING THE GENERAL PUBLIC (SCI, ENV, ENER, SEC)

- Science Museum and Laboratory Tours (20,000 people/year)
- Speakers Bureau
- BNL Videos
- Laboratory Lectures for the Public
- Community Outreach Programs
- School Mentoring Program

TECHNOLOGY TRANSFER TO INDUSTRY (SCI, ENV, ENER, SEC)

- Scientific Publishing
- Industrial Users at the Research Facilities
- Consulting by Scientific Staff
- Technology Transfer Office
  - Patenting and Licensing Office
  - Technical Assistance for Industry
  - CRADAs
  - Visiting Scientist Program with Industry
  - Research Partnerships with Industry
  - Industry-Sponsored Proprietary Research and Development
- Long Island Research Institute (LIRI) (founding member)
  - Promotes Laboratory-Industry Interaction
  - ARPA-Funded BNL/LIRI Defense Conversion Project
  - NY State-Funded Biotechnology Initiative

INFORMATION TECHNOLOGY (SCI, ENV, ENER, SEC)

- Electronic Library and Database Information Source
- Networking - "Information Superhighway"
- Technical and Scientific Publishing
- National Nuclear Data Center
- Protein Data Bank
- Data Visualization
- ALARA Center

TRAINING AND EDUCATION OF TECHNOLOGISTS (ENER, SEC, ENV)

- Safety of Soviet-Designed Reactors
- Safeguards of Special Nuclear Materials in the Former Soviet Union
- Mentoring within the DOE Complex
- Waste Management in the Former Soviet/Arctic Regions

	Science and Technology	Environmental Quality	Energy Resources	National Security
Research Facilities				
• Alternating Gradient Synchrotron	X			
• Relativistic Heavy Ion Collider (under construction)	X			
• High Flux Beam Reactor	X	X	X	
• National Synchrotron Light Source	X	X	X	
• Brookhaven Center for Imaging and Neuroscience	X			
• Brookhaven Linear Isotope Production Facility	X			
• Medical Radiation Facility				
• Brookhaven Medical Research Reactor	X			
• Scanning Transmission Electron Microscope	X			
• Protein Data Bank	X			
• Genome Sequencing Center (under development)	X			
• Tandem Van De Graaff Facility	X			
• Accelerator Test Facility				
• Center for Radiation Chemistry Research	X	X	X	X
• National Nuclear Data Center	X			X
• Booster Applications Facility	X	X	X	
• Dynamitron Accelerator	X	X		X
	X			X
	X			
Scientific Research				
• High Energy Particle and Nuclear Physics	X			
• Advanced Accelerator Concepts	X			X
• Materials Sciences	X		X	
• Chemical Sciences	X	X	X	
• Environmental Sciences	X	X		
• Medical Science	X			
• Molecular Biology and Biotechnology	X			
• Advanced Scientific Computing and Systems Analysis	X	X	X	
Technology Development				
• Physical, Chemical and Materials Science	X		X	X
• Accelerator Technology	X			X
• Environmental and Conservation Technologies	X	X	X	X
• Medical Technologies				
• Biotechnology	X			
• Safety Safeguards and Risk Assessment	X			
	X	X	X	X
Knowledge Transfer				
• Educating Future Generations of Scientists and Engineers	X	X	X	X
• Educating the General Public	X	X	X	X
• Technology Transfer to Industry	X	X	X	X
• Information Technology	X	X	X	X
• Training and Education of Technologists		X	X	X

III. LABORATORY STRATEGIC VIEW

A. Situation Analysis

1. Driving Forces

Since the end of the cold war, a major mission of the Department of Energy, its national security mission, has been undergoing a careful reanalysis. Clearly the security concerns on our nation and the resulting demands on our Department are changing. Nuclear arsenals are decreasing, weapons are being disassembled but the problems of proliferation of nuclear weapons and their technology are becoming an increasingly important part of the security issue.

It is in this context that the Department of Energy undertook a major strategic evaluation as to what should be the central missions of the Department and what should be its central core business activities. Any such redefinitions of Departmental mission and core activities clearly must involve the DOE laboratory complex, which represents the essential scientific and technological expertise of the Department. This provides an impetus for the laboratories to reevaluate and focus on their competencies and special expertise. This evaluation which is always in progress at some level, has recently moved to the forefront of our planning efforts. Our strategic vision and objectives, presented below are strongly coupled to our proposed research initiatives.

At a more local level, communities nearby major research installations are becoming increasingly sensitive to possible environmental impacts of past and present operations.

2. Planning Assumptions

The DOE is committed to support the nation's need for a strong science and technology effort to provide the base for future growth of our country. To pursue this course requires the support for basic and applied research.

There will be a need for large research facilities and smaller dedicated complexes in a broad spectrum of science and technology. These national resources will be designed and operated by DOE national laboratories for the scientific community including universities, government agencies, and industry.

There will continue to be an interest in applying world class research to problems in energy and the environment.

With the increased sensitivity to environmental safety and health issues, the laboratory continues to support technologies to improve performance in these areas. All programs now must meet ESH standards and reviews. In the environmental area there will be increased involvement of the local community.

We continue to search out directions toward more energy efficiency and alternative energy sources. We work very closely with our electrical power company to focus on ways to reduce our costs. These efforts have had positive impacts on our productivity, competitiveness and economic well being.

B. Vision and Strategic Objectives

1. General Vision

Our laboratory has, as a major core mission, its ability to design, build and operate leading edge user research facilities. These facilities serve the university and industrial scientific community well in a wide variety of scientific disciplines. We intend to utilize this expertise to operate and continuously improve existing facilities to maintain state-of-the-art capability and to create, during the next decade, the next generation user facilities of even greater power and utility.

Most of our major facilities have been or will have been built. Now in a period of budget stringency, we point out that modest upgrades of these facilities will yield large benefits and maintain their cutting edge.

Together with these facilities, we will maintain the essential world-class research efforts that are needed to drive the performance of the facilities and such other research activities as will greatly profit from a rich mix of research tools in close proximity. We pride ourselves on the ease with which creative interdisciplinary research can be done at our Laboratory. We will continue to foster that spirit and culture at our Laboratory. We plan to play a major role in providing the underlying science and technology for the DOE missions in basic and applied research, energy and environmental sciences, materials science and biotechnology sciences.

As the changing world has fundamentally altered the U.S. posture on nuclear weapons, we have a special niche in the national security area. Brookhaven has a long tradition of impartial thinking on arms control and nonproliferation technology, the sector of expanding interest for the U.S.

In ESH the Laboratory's vision is to achieve the same level of success in ESH that we have achieved in our research endeavors. We intend to achieve this vision through a structure of effective procedures, by having trained and qualified personnel and by continually analyzing our ESH performance. We will work with the local community, which is concerned about possible environmental impacts from our operation, providing open interaction and dialogue with the community.

2. Program Specific Objectives

Nuclear Physics

By 1999, BNL will offer two important user facilities to the nuclear physics community: 1) the Alternating Gradient Synchrotron (AGS) machine with its complement of particle and heavy ion beams; 2) the Relativistic Heavy Ion Collider (RHIC) with its high energy colliding beams of heavy ions and polarized protons. The former facility allows the exploration of nuclear forces by means of the formation and decay of hypernuclei containing strange quarks, as well as the study of other interesting processes of nuclear physics best explored with hadron probes. RHIC will supply colliding beams of heavy ions to explore the highly relativistic regime of nuclear collisions in which the incoming beams of ordinary nuclear matter melt during the beam collisions into a quark-gluon plasma. Such extreme nuclear conditions existed in nature only during the primordial 'big bang' that created the universe. RHIC will fulfill the needs for a research program described in the 1983 Long Range Plan for Nuclear Physics as "the highest priority new scientific opportunity within the purview of our science". Since its infancy in the early 1980's, this area of nuclear physics has grown to be one of the major components of the national effort. RHIC will also supply colliding beams of highly polarized protons in which spin-related Quantum Chromodynamic behavior of quarks and gluons can be measured for the first time in a reliably calculable manner. Interest in this area of physics is also growing rapidly in both the nuclear and high energy physics communities.

High Energy Physics

The continuing intensity improvements of the AGS machine allow users to expand their capability for exploring several important particle physics phenomena. One example is the measurement of rare kaon decay channels that offer some of the most sensitive probes to challenge predictions of the "Standard Model" (SM) of high energy physics. Exploring the limits of applicability of the SM is one of the main continuing goals of High Energy Physics (HEP). The kaon experiments will continue to extend their sensitivity and physics reach as the AGS continues to increase its intensity. Other interesting experiments in progress and contemplated include a measurement of the muon "g-2" value and various hadron spectroscopy measurements connected with searching for "gluonium", "strangelets" or other exotic states of matter. We recently had an AGS 2000 workshop which looked into possible experiments to be done at the AGS utilizing the high intensity beams. Several exciting physics proposals are expected to be submitted for consideration by the Physics Advisory Committee. The Center for Accelerator Physics at BNL will continue to explore the boundaries of particle accelerator technology with possible applications in electron, muon and proton colliders of the 21st century. Finally, we note that in this era of internationalization of big science, BNL will continue and incrementally expand its involvement with HEP activities away from Brookhaven. In addition to continuing our productive involvement in the D0 Experiment at Fermilab (where discovery of the top quark was recently announced), we note our plans to participate in both the accelerator and ATLAS detector aspects of the Large Hadron Collider (LHC) at CERN in Switzerland, a very large international effort devoted to exploration of the "Higgs Sector" physics. Discovery of the Higgs particle(s) or the breakdown of the Standard Model of physics is the scientific attraction of this program. BNL will also play a role in the construction of LHC utilizing BNL's strong superconducting magnet R&D expertise.

Basic Energy Sciences

Brookhaven is unique in having user facilities which provide intense beams of the four main probes used to study condensed matter: photons, neutrons, positrons and electrons. The National Synchrotron Light Source has two storage rings which provide intense beams of light from the infrared to the ultraviolet to the x-ray region of the electromagnetic spectrum. The High Flux Beam Reactor is one of three high flux reactors worldwide, and it supplies beams of both thermal and cold neutrons. A high intensity positron facility uses a copper isotope produced in the HFBR as a source. The recently commissioned Center for Radiation Chemistry Research provides short intense pulses in electrons which are used for pulsed radiolysis experiments. A new transmission electron microscope with 0.2nm resolution is being purchased to add to the suite of facilities for studies of condensed matter. The core research programs, which are mostly built around the facilities, include the fundamental understanding of the structure and properties of surfaces, interfaces, and novel materials; basic and applied research on superconductivity and magnetism; chemical science of molecular photochemistry and reactions, and programs in catalysis, electrochemistry and environmental research. These facilities and core research programs form the nucleus of a large user program which includes scientists from university, industrial and other government laboratories. We look forward to the continuing strength of both of these leading to new results which will be critical to the long term scientific and technological health of the country.

The National Synchrotron Light Source has an enviable record of providing highly reliable and stable beams of photons to over 80 beamlines for more than 5000 hours per year. With continuing improvements including higher current and/or higher energy operations, lower emittances, and new insertion devices, the NSLS is approaching the capabilities of the new synchrotron sources in many areas. The scientific facilities initiative provided funds to enhance beamline capability and to provide a larger number of beamline scientists to support the user program. The Participating Research Teams and the NSLS are working together to improve the efficiency of beamline operation in a number of key areas. Together these developments will ensure that the NSLS remains a

user friendly, cost effective source of synchrotron radiation for the ever increasing user community well into the 21st century.

For several years the NSLS has been a major contributor to a national effort in free electron lasers aimed at the development of fourth generation light sources. The R&D is being done both at Brookhaven's Accelerator Test Facility and at the NSLS Source Development Laboratory. Most of the major components have been assembled to do key demonstration experiments in the ultraviolet in the coming years, and we and our collaborators around the country continue to request funds from the DOE to keep the U.S. at the forefront of this field.

Our activities in the area of neutrons have been centralized with the formation of a Center for Neutron Science. The Center has responsibility for 1) enhancing and overseeing the general user program at the HFBR, 2) developing plans to upgrade the High Flux Beam Reactor, and 3) participating in a national effort to develop the next generation of spallation neutron source. The HFBR operated for approximately 6500 hours in FY95 at a power level of 30MW. The general user program has been expanded with the addition of 3 new instruments which brings the total to16. Partially through the scientific facilities initiative four beamline scientists are funded to support the new facilities. In the coming year there will be further increases in available instruments through the addition of thermal guides, and we anticipate substantial increases in the user program.

A proposal to upgrade the HFBR has been made to the DOE. It would include: 1) replacing the reactor vessel, 2) lengthening the beam thimble that contains the cold source so as to optimize its performance, 3) building a guide hall which will contain neutron guides to provide cold neutron beams to 16 instruments, 4) returning the reactor to the 60MW power level at which it operated for almost a decade, and 5) providing enhanced safety features to further minimize possible environmental concerns. This upgrade would give the U.S. an I.L.L. equivalent steady state neutron source well into the 21st century. A scoping study suggests that the TPC for this upgrade would be $180M and it would take 5 years of which the reactor would be out of service for 2 years. BESAC appointed a committee to study possible upgrades of the DOE research reactors and the committee and subsequently BESAC have strongly recommended that the DOE proceed with a full conceptual design report for the HFBR upgrade.

Steady state and pulsed neutron sources are complementary, and access to a powerful pulsed spallation neutron source, PSNS, is also necessary for sustained progress in neutron science. The Energy and Water Appropriations Bill for FY96 and the DOE give support for the design of the next generation PSNS, and at the same time look at options for cost effective interim sources at the level of the present world leader ISIS in the U.K. The present average proton power of the AGS (140KW) at 7 GeV is comparable with ISIS (160 KW). The distribution of proton pulses can be varied so that the peak power delivered to the target can be varied from that expected for the next generation PSNS down to that at ISIS. As a result the AGS provides a unique opportunity for the U.S. neutron community to develop the targets needed for the new source while providing an interim source comparable to ISIS. In addition there are a number of enhancements to the existing AGS accelerator complex that could double or quadruple the average proton power at modest cost. A scoping study of a target and beamline development facility gives an approximate TPC of $120M with no accelerator enhancements and $180M for a 280KW facility. We are working with ORNL, which has been designated as the lead laboratory, on the design of the new PSNS based on our accelerator expertise and building on our earlier green field design for a 5MW spallation source.

Medical Technologies

We are developing a Brain Imaging Center based upon PET scanning and functional MRI at BNL. The Center will make significant advances in the elucidation of the basic mechanisms in substance abuse and in the search for pharmacological agents of use to counteract the craving for abusive substances. The Center

will also include an advanced SPECT Laboratory that will enable the Center to transfer the findings from PET and MRI to SPECT so as to make the findings readily available to almost all Medical Centers (PET and functional MRI are few and far between). The Brain Imaging Center will be used to develop new forms of imaging combining PET and MRI and will be dedicated to basic research in the neurosciences.

Cancer therapy as exemplified by Boron Neutron Capture Therapy (BNCT) has gone through preliminary Phase I/Phase II trials that have demonstrated that BNCT is safe and without adverse effects at the doses given. These are being followed by further trials to improve efficacy over conventional therapies. Other tumor localizing drugs will be sought for use in neutron capture therapy and to treat malignancies in tissues other than brain.

We envisage BNL being a National Isotope Center supplying radioisotopes to the medical and research community for a number of years until the need and/or the market demonstrates the desirability of going to devices with a capacity greater than available at BNL. Radioisotopes and ligands for radioisotopes will be developed for tumor diagnosis, palliation, and therapy.

Research studies at the NSLS on human coronary disease are planned using the intravenous coronary angiography station. Research is being done using photon microbeams for possible long term cancer therapy and also on photon activation therapy.

Genome Sequencing and Structural Biology

We are developing improvements in DNA sequencing technology, based on the automation of the primer-walking methodology developed at BNL. As our sequencing capacity increases, we plan to become a major Genome Sequencing Center. This Center will have natural interactions with our programs in molecular genetics, structural biology and the Protein Data Bank. We plan to establish a substantial effort in informatics and computational biology to develop new ways to manage, understand and exploit the coming flood genomic information, and to begin to bridge the gap between sequence and structure.

Environmental Research

Brookhaven's environmental research program has two goals - studies of the climatic and biological effects of energy use and advancing the science and technology of the remediation of radioactive and other wastes.

The Laboratory has integrated research capabilities in atmospheric science, oceanography, and terrestrial ecology. In addition, we have major programs in waste management which include chemical and nuclear waste disposal, high level waste tanks, and bioremediation.

Energy

Research and technology development in the area of energy resources continues to be of great concern, with both economic and national security implications as more countries attempt to duplicate the standard of living in the US, Western Europe, and Japan.

Brookhaven is in the forefront in the application of biotechnology and modern methods of risk assessment to fossil energy and has an important program in geothermal energy as well. We have made major contributions to the improvement of efficiency in residential heating systems and are currently involved in studies of the losses connected with thermal distribution systems.

Nuclear Safety

BNL assists the Department of Energy (DOE) in areas related to nuclear safety policy and standards applicable to DOE nuclear facilities. The Laboratory provides technical and analytical support to DOE in reviews of Environmental Assessment/Environmental Impact Statements, and Deactivation, Decontamination, Decommissioning, and Dismantlement Reports. In a related activity, BNL also conducts a substantial analytical and experimental program for the Nuclear Regulatory Commission (NRC) covering the full spectrum of safety concerns for operating and advanced nuclear reactors.

National Security

Brookhaven has a long tradition of expertise in safeguarding of nuclear materials and has worked for many years supporting the International Atomic Energy Agency efforts. With the changing national security missions of the DOE, our expertise is perfectly suitable to address the emerging central issue of the proliferation of nuclear weapons. Many of these technologies are also applicable to the area of arms control of chemical weapons. We expect to have a expansion in the arms control program and related areas such as weapons disposal.

C. Strategic Issues

Our Laboratory is planning to go through a major transition in 1999, when the funding landlord changes from High Energy Physics to Nuclear Physics. This will also precipitate a substantial change in the operating budgets in those two areas. High Energy programs will then pay the incremental costs to operate the facilities while Nuclear Physics will support the base program. These changes are discussed in greater detail in the science and technology program section of the Institutional Plan. We must accomplish this transition in a smooth manner that preserves the excellence of both programs, both of which will be unique for the nation.

We are concerned about the continuing problem of the difficulty of making the transition from a construction project to an operating facility. Operating funds for both existing and new facilities have been too low for optimum use of the facility. That has been a chronic problem across many program lines.

We are concerned about the climate that looks for a fast payback on research. We must continue to educate the public that basic research payoffs take longer and are less easily connected to the primary research, especially before the fact. Historical experience should be used to defend the critical and fragile nature of basic research.

D. Managerial Strategy

As managers of a multiprogram laboratory that endeavors to respond to a broad spectrum of national needs, we must preserve a free and open atmosphere so important to continue the basic and applied programs carried out with a large number of visitors. We believe the involvement of the user community and the non-management scientific staff in planning decisions is critical to maintain a vibrant research program. To this end, we have fostered strong user groups at each of our facilities and actively encourage their participation.

We are strengthening the Laboratory's commitment to environmental protection and safety by bringing our programs to a state of full compliance with federal, state and local requirements. Our goal is to achieve the same level of success in safety and environmental matters in the cost effective manner that we have achieved in our scientific endeavors.

To enhance our contributions to American economic competitiveness and to aid in the utilization of our research achievements by American industry, we must go beyond just making our staff sensitive to the economic impact of their work. We must form closer alliances and collaborations with the business sector so as to be more cognizant of their needs. The Long Island Research Institute, founded by BNL, along with the State University of New York at Stony Brook, and Cold Spring Harbor Laboratory is an important step in that direction. This non-profit institute is becoming an additional bridge to the private sector and has as its mission the transfer of technology from the founding institutions to industry.

We are also involved with the working committees of the Long Island Association, the major Long Island business association.

Finally, we note that it is a challenge to keep intact the corps of specialized scientists and engineers experienced in the construction and operation of large technical facilities in the face of drawn-out or delayed construction projects. We will continue to play a role in the education and training needed to preserve a national capability to build complex facilities to meet scientific, industrial, and national security needs.

IV. INITIATIVES

This section contains major initiatives which are important to maintain and expand our capability to carry out our strategic missions. Initiatives are provided for consideration by the Department of Energy. Inclusion in this plan does not imply Department approval of or intent to implement an initiative.

BASIC ENERGY SCIENCES (KC)

The High Flux Beam Reactor is one of the premier world-wide sources of intense neutron beams for scattering experiments in nuclear and condensed matter physics, structural biology and chemistry, with additional state-of-the-art facilities for isotope production and materials irradiation. Over the last few years, the HFBR has run predictably and well, and several modern new instruments have been added to broaden the user base of the facility.

We believe that the HFBR is capable of reliable operation for another decade or more without major replacements, and the HFBR should continue to be a mainstay of the U.S. neutron community for the foreseeable future. Moreover, with the cancellation of the Advanced Neutron Source (ANS), the HFBR is capable of an expanded role. Refurbished by replacing the containment vessel, and an improved cold-neutron moderator and guide hall, the HFBR would be a facility on par with the Institut Laue-Langevin (ILL), presently regarded as the best in the world.

We have carried out a preliminary study of such a refurbishment project, with the help of a major international construction firm (Gilbert/Commonwealth), which concluded that it was technically feasible. This study, upon further peer-review and refinement, was the basis of a proposal to the Basic Energy Sciences Advisory Committee (BESAC), asked by DOE to make recommendations concerning U.S. neutron facilities for the next century. BESAC endorsed the importance of the upgrade plan, and recommended that DOE proceed without delay to fund the design study of the project to establish reliable cost estimates. On this basis we are putting forward a construction initiative for the HFBR Upgrade. (See Construction Initiatives.)

Steady state and pulsed neutron sources are complementary, and access to a powerful pulsed spallation neutron source (PSNS) is also necessary for sustained progress in neutron science. As a result of our experience and expertise in this area, we are collaborating with other DOE laboratories in a design study led by Oak Ridge National Laboratory to produce a reference design for a next-generation PSNS ultimately capable of delivering time-average proton power in the 1-5MW range.

We have also studied the feasibility of modifying the existing AGS complex to produce a PSNS. With minimal incremental funding, the AGS complex could deliver powerful proton pulses (exceeding 100 kJ per pulse) presently unavailable elsewhere in the world, and capable of being developed into a facility for both the testing and productive use of state-of-the-art neutron targets and instrumentation. The use of the AGS for this purpose would be compatible with its essential role as an injector for RHIC, and with a continuing high-energy physics program on a time-shared basis.

Construction Initiative

HFBR Upgrade

The HFBR is one of the world's best neutron sources, comparable to the reactor at the Institut Laue-Langevin (ILL), but lacking that facility's investment in user instruments. As previously discussed, we have developed a plan to upgrade the HFBR which would rectify this imbalance, and which has been endorsed by the Basic Energy Advisory Committee. Briefly, the plan would replace the existing reactor vessel, thereby extending its useful operating life-time for another 25-30 years. At the same time, a small modification of the vessel design would

allow it to be fitted with a much improved cold-neutron moderator, together with a neutron guide hall complete with 15 new cold-neutron user instruments. The minor changes in the design of the reactor vessel would neither alter the HFBR's basic internal structure nor require modifications of operating procedures. None of the modifications would expand the safety envelope of the HFBR, and no new or unreviewed safety questions should result. We will, however, give special consideration to methods of further reducing tritium emissions, which have become a focus of local community concern.

Our plan consists of a one-year Conceptual Design Phase (FY97), followed by a two-year Detailed Design Phase (FY98-99) and a four-and-1/2 year Construction Phase (FY00-04). The HFBR would be off-line for two years, returning to operation in mid-FY03, with the new cold-source and about half of the new instruments in operation. The Total Project Cost (TPC) is estimated at $182M (FY96), with incremental Line-Item funding of $140M. The remaining $42M would come from projected current-level HFBR facility operating funds. The preliminary funding profile for this project is shown in accompanying table.

HFBR Upgrade
RESOURCE PROJECTIONS
($ in Millions - B/A)
Fiscal Years

	1997	1998	1999	2000	2001	2002	2003	2004
OPERATING	5	--	--	--	--	--	--	--
CONSTRUCTION*	--	15	--	--	--	--	--	--
TOTAL	5	15	--	--	--	--	--	--

*Estimated construction funding profile for FY98 only - outyear funding yet to be determined.

Construction Initiative

AGS Spallation Neutron Source

The Brookhaven National Laboratory AGS complex (comprising a 200 MeV linac, 1.5 GeV AGS) has many advantages as a facility for both the development and productive use of spallation neutron targets, moderators and state-of-the-art neutron instrumentation. Chief among these advantages is the existing AGS complex which, with minimal incremental funding, is capable of providing 140 kW proton beam power for a spallation neutron source (SNS) equal to the best in the world (ISIS at 160 kW) and also capable of producing powerful proton pulses (exceeding 100 kJ per pulse) not presently available elsewhere in the world. Such powerful beams will be necessary to develop target and moderator designs for next-generation spallation neutron sources (SNS). The use of the AGS for this purpose would be compatible with its essential role as an injector for RHIC, and could also be compatible with a continuing high energy physics program on a time-shared basis.

Opportunities exist for projects which vary considerably in scope and cost. Construction of a basic Test Facility would involve simple accelerator upgrades, extension of a beam transfer line and construction of a target area with minimal general purpose shielding. It would provide 100 kJ proton pulses on a single-pulse basis, which could be used to validate, test and optimize next-generation SNS target and moderator design concepts for a (possibly international) consortium of interested spallation source designers. Such a Facility could be upgraded incrementally as appropriate as the experiments progress. Adding shielding necessary for continuous multi-pulse operation together with target, moderator and four user instruments could result in a 140 kW (ISIS-class) facility, with an initial complement of user instruments. Further upgrading with an accumulator ring to deliver 280 kW beam power, adding a second moderator and an expanded suite of instruments would provide a powerful SNS which would meet or exceed the performance of any presently existing facility. Which options BNL chooses to pursue will be driven by the developing needs of the spallation source community.

Construction Initiative

NSLS Phase III Upgrade

The purpose of the Phase III upgrade of the NSLS is to maximize the scientific output of the facility. Considerable investment by both the Department of Energy and the facility's Participating Research Teams has permitted the NSLS to offer a national facility to a wide range of scientific pursuits. With machine reliability issues having been addressed improvements in beam intensity and stability would continue and enhance the NSLS's role in synchrotron radiation research.

On the UV ring, the proposal concerns the upgrade of four of the 25 beamlines which are presently installed and operational on the NSLS VUV ring. The four beamlines targeted for upgrades, U3C, U4A, U8B, and U12, all support strong scientific programs but are producing less optimal science because of outdated monochromators.

Monochromator and optics designs have qualitatively improved in the last ten years, and the increased photon energy resolution resulting from upgrades allow state-of-the-art electron spectroscopies (e.g. *high* electron energy resolution angle-integrated photoemission) to be performed on these beamlines. Furthermore, the flux at the sample will be greater, at a given photon energy resolution, with the upgraded beamlines because they will be able to provide the desired resolution at full acceptance (i.e. there will no longer be a need to mask the optics in order to achieve better resolution). The ability to fully accept the radiation emitted from the ports on the VUV ring is provided by the superior optical design of the new monochromators and by the superior figure and finish of the new gratings and mirrors.

On the X-ray ring, the proposal concerns the upgrade of twelve of the 60 beamlines which are presently installed and operational on the NSLS X-ray ring. The principal motivation of the x-ray beamline upgrades is to take advantage of qualitative improvements in x-ray optics and detectors. In particular, x-ray mirrors will be replaced on the most productive and well equipped beamlines of the 2.5 GeV ring and will cover the experimental areas of x-ray spectroscopy, x-ray scattering for chemical and materials sciences, biostructural studies and x-ray imaging.

Machine upgrades will focus on photon beam position monitoring systems on both the UV and X-ray; new rf cavities/transmitters and an insertion device for the X-ray storage ring.

High resolution monitors (< 1 micron) will be added to each available port on the machines to provide an independent measurement of the position of the photon beam as it is delivered to the user.

The X-ray storage ring has four 52.88 MHz cavities that are approximately 12 years old. These cavities have in their design water to vacuum welds which due to the age of the cavities are considered a potential problem. Two of the four are presently being replaced with ARAM funds and the replacement of an additional two are contained in this proposal. In addition each cavity is powered by a 125kw transmitter that runs in excess of 80% available power in order to meet the machine design current of 500 mA. By adding two additional transmitters an individual transmitter fault would reduce the likelihood of beam loss or fluctuation.

Using Laboratory Directed Research & Development (LDRD) funds, a prototype 'small gap' undulator was designed and constructed. This device has operated at a gap of less than 4mm without affecting the electron beam. Based on the success of this device, a new insertion device will be installed on X25, and it will have half the gap of the existing device, half the period but the same overall length and the same peak field. This will directly increase the brightness by a factor of two without additional heat load on the x-ray optics. This will be important for the entire scientific program on the X25 beamline.

Over the years, the NSLS has experienced unscheduled downtime due to voltage transients on BNL's power feeder. These transients are normally only several hundred milliseconds in duration, but cause hours of downtime

due to the necessity of restarting all of electrical systems involved in ring operation. Recently a superconducting magnet energy storage (SMES) system was developed for the U.S. Air Force. The unit can support a power level of 1.4MW for up to 1 second which is enough to protect the VUV ring which runs at a power level 800kW. The unit was aquired from the U.S. Air Force and is being tested on the VUV ring. If this is successful, then a larger unit would be acquired for the x-ray ring.

A 9,400 square foot second floor over the X6- X16 region of the facility is planned. This space would be divided into a 3,100 s.f. addition that would provide twelve offices and one conference room and a 6,300 s.f. open landscape addition that would be modularly developed by the user community.

NSLS Phase III Upgrade
RESOURCE PROJECTIONS
($ in Millions - B/A)
Fiscal Years

	1997	1998	1999	2000	2001
CONSTRUCTION	--	--	7.6	15.5	4.8

Construction Initiative

NSLS Free-Electron Laser and Source Development Laboratory

The proposed BNL, DUV-FEL will provide picosecond and sub-picosecond pulses of coherent ultraviolet radiation for wavelength from 300 to 75nm, single pulse energies of > 1mJ with repetition rate of 360Hz. This "Fourth Generation" source will make possible new avenues of inquiry in time resolved studies of diverse fields including chemical, surface and solid state physics, biology and material science. BNL provides a natural home for such a facility, since much of the core research community the FEL will serve already uses facilities at BNL. Support of general users also comes as a natural extension of the well-established infrastructure for such endeavors already extant at the NSLS and BNL in general. Support for research and development for such a facility has been endorsed by the recent National Academy of Science study.

Early development of the scientific program envisioned for the new facility can be started at the NSLS by building a new beam line designed for 400-2500Å photons utilizing the U13 undulator on the VUV ring. In addition, the 230 MeV linac funded by DARPA as part of the SXLS project can be adapted to build a UV-FEL. This would initially allow demonstration experiments to be performed, leading to user experiments later on.

Accelerator and FEL physics R&D are being done at the BNL Accelerator Test Facility to provide the proof-of-principle technology for the DUV-FEL. This work includes a high-brightness laser-photocathode RF gun, a high gain harmonic generation FEL experiment, superconducting wiggler magnets, a visible to near UV FEL Oscillator experiment, seed laser technology and more.

Studies are underway to develop the design and performance characteristics of an accelerator-based UV/VUV radiation source that will provide picosecond and sub-picosecond pulses of coherent ultraviolet radiation for wavelengths from 300 to 75 nm. Pulse width will be variable from about 6 ps to under 150 fs, with high repetition rates, a 10^4 bandwidth, single pulse energies > 1mJ and hence peak pulse power, from 140 MW at 75 nm to over 1 GW at 250 nm.

The electron beam is generated by a high duty factor laser photocathode RF gun. The radiation is generated by tunable Ti-sapphire lasers, multiplied by conventional techniques to the visible or near UV. This radiation is

then injected into the bunching section of the undulator, which is resonant at the injected radiation's frequency. The energy modulated electron beam is bunched magnetically and fed into the next undulator section, now resonant at a VUV harmonic of the seed radiation. The radiation is now amplified, first in an exponential section, then in a tapered undulator section and transferred to the users. By synchronously tuning the seed laser and modulating the energy of the electron beam, wavelength tuning is possible.

The DUV-FEL, will use the DAPRA s-band electron linac upgraded to a pulse repetition rate of 360 Hz and an energy of 300 MeV. It will also use the present linac building, across the street from the NSLS.

The coherence and wavelength stability of the seed laser is preserved by the FEL harmonic generator/amplifier. The Deep Ultra-Violet Free-Electron Laser proposed by BNL represents a qualitative advance in the capabilities of VUV radiation sources. This region of the spectrum covers valence and shallow core level electronic processes. The intense DUV radiation of this source can be utilized to push the frontier of science in many fields including chemical, surface, and solid state physics, biology and material science.

NSLS Deep Ultraviolet Free-Electron Laser User's Facility
RESOURCE PROJECTIONS
($ in Millions - B/A)
Fiscal Years

	1998	1999	2000	2001	2002	2003
CONSTRUCTION	--	--	13.7	17.3	15.9	6.1

SITE REJUVENATION

MEL/FS AND GPP INITIATIVE (KA, KG)

Multiprogram Energy Laboratories - Facilities Support (MEL/FS)

Strong support for infrastructure renewal is needed. With a backlog of over $150M in GPF and ES&H projects, we are concerned about the impact a reduction of funding to below historical level would have. It is important that our proposed program for FY96 be supported in order to be able to continue those projects in process and also allow for the start of needed improvements to Building 801.

FY	PROJECT	TEC ($M)	FY 1996 ($M)
1994	Fuel Transfer Facility (In Title II Design)	3.6	0.4
1995	Applied Science Center I	3.9	3.3
1995	Sanitary System Upgrade II	4.3	1.7
1995	Loss Prevention Upgrades I	7.7	2.5
1996	Hot Lab Renovation B/801 Ph I	7.1	0.8

The above FY96 program will generate a modest mortgage of $11.2M in FY97. If the funding remains at the current projected levels, it will leave the Laboratory with no new starts in FY97.

A significant expansion in MEL/FS program is needed in the FY96 planning period to reduce the current backlog of infrastructure needs and to meet new requirements. No significant progress can be made in either ES&H backlog reduction or infrastructure renewal without the expansion of the MEL/FS program. Without capital investment, maintenance requirements are certain to increase and economical replacement opportunities will be lost.

General Plant Projects (GPP)

The increase in GPP project Total Estimated Cost (TEC) to $2.0M, will allow urgent projects costing less than $2M to be addressed with GPP funding.

GPP has been and will continue to be the mechanism for addressing short term infrastructure and ES&H capital needs. During the past five years, the unfunded backlog has averaged $27M. While the increased project ceiling will help in many ways, it will also generate an increase in the project backlog as some project needs are moved from other capital construction programs to GPP. A reasonable increase in GPP funding would significantly effect the Laboratory's ability to manage the GPP backlog. If the funding level were increased to $10M annually, it would allow elimination of most of the backlog over the planning period.

V. SCIENTIFIC AND TECHNICAL PROGRAMS

A. DOE PROGRAMS

ENERGY RESEARCH

HIGH ENERGY PHYSICS (KA)

The high energy physics program at Brookhaven consists of several components. The largest is the operation of the Alternating Gradient Synchrotron (AGS) and support for the experimental pro-gram there. This is a forefront program serving a very large community of experimental physicists probing fundamental issues of particle physics. There is a strong in-house program of research, most of it carried out at the AGS. Most of the AGS experiments have BNL participants, though BNL staff make up only about 13% of the total number of users. There are important R&D programs in advanced accelerator design, and detector development. An important focus of the current advanced accelerator R&D program is a feasibility study for a muon-muon collider facility in the multi-TeV energy regime. The AGS Booster has increased the AGS intensity by a factor of three. The AGS currently accelerates up to $6x10^{13}$ protons per pulse, the world's highest intensity proton synchrotron. Designs for an Accumulator Ring to provide 8-20 microamperes extracted current are presently under study along with other incremental improvements to the AGS. A possible proposal for construction to be submitted to the DOE in the future is under consideration.

ALTERNATING GRADIENT SYNCHROTRON

High Energy Facilities (KA-02)

Brookhaven is one of three DOE institutions serving the needs of the national high energy physics program. Major improvements have been and are being made to the AGS to support an active research program with forefront experiments. At other laboratories, the frontiers of the field are explored using the highest available collision energies; BNL supports experiments of unique sensitivity utilizing BNL's high intensity beams (examples: rare K meson decays; muon (g-2) value). These experiments are carried out at intermediate beam energies and seek answers to fundamental questions addressed as part of the national HEP program.

Over 930 experimental physicists worldwide are making use of the AGS facilities at the present time and the program is extremely active. For the main proton beam program the beam intensity has reached a record of 6.0 x 10^{13} protons per pulse, with seven forefront experiments using this beam simultaneously. The AGS also has accelerated polarized protons to 22 GeV energy with 45 percent polarization, a unique capability, and improvements are being made to increase the energy and the polarization to still higher levels. Branching out into the field of High Energy Nuclear Physics, the AGS now routinely accelerates gold beams injected from the Brookhaven Tandem Van de Graaff [TVDG]), to an energy of 11.7 GeV/nucleon. The third generation of several large scale experiments, as well as many small exploratory experiments, have begun in the entirely new field of research on high density states of nuclear matter, the quark-gluon plasma, and strange matter. RHIC, scheduled for completion in FY99, will not only provide ion-ion collisions, but will also have the capability of providing proton-ion and proton-proton collisions, the latter at a center-of-mass energy of up to 500 GeV, luminosity up to $5X10^{32}\cdot cm^{-2}.sec^{-1}$, and beam polarization up to 70%. This capability will provide some important opportunities in elementary particle physics, such as the study of the role of spin in very high energy hadron physics. The AGS began to serve the radiobiology community in FY 95 with 1 GeV/AMU Fe beams. This program is supported on a full cost recovery basis by the National Aeronautics and Space Administration.

The AGS Booster is now operating at 50% above the design intensity level. The Booster addition allowed the intensity of the proton beam in the AGS to rise by a factor of 3. It has enabled heavy ion species up to gold to be injected into the AGS and it will serve as an accumulator for polarized protons. The Booster is an essential component of the plan to expand the reach of the rare kaon decay research program, improve nuclear physics research at the AGS and, ultimately, enable the AGS to inject intense beams into the RHIC.

An active Accelerator Improvement Program is necessary to upgrade or replace older AGS systems, and large capital programs are required for the experimental areas, in order to adapt the existing facilities for new requirements. The heavy ion capability, initially serving the fixed target program on the AGS experimental floor, will lead toward colliding beam physics in the RHIC. RHIC will provide counter-rotating colliding beams of heavy ions up to Au, which will be injected from the AGS and then accelerated to 100 GeV/nucleon. This will be by far the highest collision energy for heavy ions avail-able anywhere in the world thereby enabling the U.S. to assume the role of world leadership in the rapidly growing field of research on high density states of matter and the quark-gluon plasma.

Brookhaven National Laboratory has assumed world leadership in providing a "kaon factory" in order to meet the needs of modern high sensitivity experiments in the intermediate energy range. There have been a number of proposals to construct enhanced "kaon factories", new proton accelerators of energy comparable to the AGS but with a factor of 50 higher beam current than the AGS provides. One of these plans, KAON in Canada, had reached the stage of tentative approval, but less than half of the funding was committed by the Canadian Government. The second is the Japan Hadron Facility, JHF. The KAON proposal was cancelled by the Canadian Government. The JHF proposal has yet to be fully funded. In an initial response to that need, BNL has completed the construction of a Booster which has increased intensity of the AGS by a factor of 4. In our continuing program of intensity upgrades of the AGS, the next improvement will result from implementation of the "RF Barrier Bucket Cavity" improvement which will increase the AGS intensity by a factor of 1.7. As a new construction initiative, BNL is also considering the option of building an "AGS Accumulator Ring" which would increase the beam current by another factor of two, increasing the beam delivery duty cycle to nearly 100%, for a total intensity improvement factor of 8-10 over the pre-Booster capability of the AGS. This would create a "Mini KAON Factory" in a step-by-step approach, developing a new and unique facility by improving and adding to existing assets. The decision on whether or not to pur-sue the Accumulator will be program driven.

The ongoing physics program at the AGS is very active, and it supports research at the frontiers of both high energy elementary particle physics and high energy nuclear physics. The High Energy Physics Advisory Panel stated at its January 28-29, 1994 meeting that,

> "Our general impression of the BNL program was that it is broad and diverse and addresses many key questions in both physics and technology. Even though the Rare K Decay Program is frequently viewed as the flagship effort of the AGS activities, there are a number of other important experiments which are unique in the world; muon g-2, glueball searches, spin physics, and strangelet searches are some of the examples we have heard about.
> One of the strengths of the U.S. effort in high energy physics has traditionally been its diversity even though there are costs associated with it. The AGS program makes an important contribution to this diversity. The AGS operation started in 1961, over thirty years ago. It has had a rich history of accomplishments including three experiments recognized by subsequent Nobel prizes. Today it is still capable of addressing many frontier questions, mainly because several extensive accelerator upgrade programs in the past, culminating in the recently completed Booster, have modernized the machine and significantly enhanced its capabilities. We hope that this broad program of experimental activities based on the AGS can continue as long as physics warrants it."

Future improvements are underway or are proposed as new construction initiatives, and in both fields of research the experimental physics community is anxious to exploit these new facilities and to see where the

experimental research leads them. One proposal that is under active investigation is the use of the AGS as a proton driver for a muon collider machine of 250 GeV x 250 GeV at a luminosity of 10^{35} cm^{-2} sec^{-1}. One can already envision further facility improvements starting after the scheduled completion of the RHIC (1999) and of the possible AGS Accumulator Ring, but a step-by-step ap-proach seems preferable, so that further developments are always guided by progress in the research program.

BNL recognizes the possibility of major changes in the AGS HEP Program at the time of transition to RHIC and indicates in the following the present planning strategy. In line with the HEPAP Subpanel report of 1992, we had anticipated running a total of 25 weeks per year during FY94-96. Budgets actually limited running time to 13 weeks in FY94, 24 weeks in FY95 and 12 or possibly 16 weeks in FY96. We expected to have largely completed our currently scheduled rare kaon decay program during that time period and hopefully started on running the g-2 experiment. Completion of the g-2 experiment is unlikely prior to FY99 because of the great difficulty in understanding all of the system-atic errors which may be present and because the experiment will require the construction of a muon injection system to achieve full sensitivity. A number of other new experiments (or extensions of existing experiments) are under study by the AGS user groups. None have yet been considered or approved by the Laboratory.

We note that the FY99 completion date of the current program is predicated upon 25 weeks of AGS operations per year from FY95 to FY99. The High Energy Physics Advisory Panel also observed at its January 28-29, 1994 meeting that,

> "We urge that funds be found to run the AGS 20 to 25 weeks a year. Over the last few years major investments have been made in improving the AGS and increasing its intensity by addition of the Booster; in addition major efforts were made towards construction or significant up-grades of the beamlines and the detectors. It is essential that these investments and the many physics opportunities available be exploited. We point out that the program is very highly leveraged; relatively small additional funds are needed to double the currently foreseen AGS running time."

A year later, noting that funding for BNL's HEP program seemed to be trending sharply downward, the HEPAP commented in its March 23, 1995 letter to Martha Krebs that,

> "Probably our major concern regarding the DOE HEP budget concerns the Brookhaven situa-tion. The long range funding profile for that laboratory planned a few years back assumed a 1997 start-up of the RHIC and a turnover of primary responsibility for the Brookhaven Alter-nating Gradient Synchrotron (AGS) to the Nuclear Physics Division at the same time. In light of the DOE funding driven slippage of the RHIC completion date to 1999, it is appropriate to reexamine these profiles again so as to assure optimum physics output from the BNL HEP program".

We have initiated steps to improve this prospect and return the program to the basis noted in the previous year's HEPAP statement.

The presently approved and funded program will meet the FY99 HEP program completion date provided the AGS running hours are actually available. We also note that planning for AGS opera-tions should involve both DHEP and DNP. The necessity of and ability to support RHIC is the driving term for any incremental high energy operations of the AGS machine beyond FY98. The precedent for such incremental operations support at the AGS was set in FY86 when fixed target heavy ion physics began at the AGS.

The Division of Nuclear Physics (DNP) will be responsible for the base costs of operating the AGS as an injector to RHIC. The incremental costs to the DHEP to support a fixed target physics program at the AGS is very dependent on the extent (number of weeks of operation, number of experiments supported), type of operation (slow extracted beam, SEB, fast extracted beam (FEB), and the DNP support of test beam operations for RHIC

experiments. In response to the DHEP request for the BNL transition plan from DHEP to DNP operations we present the details below.

The DNP costs to support injector operations, including the Tandem, is estimated to be $27.8M (FY98$). The DNP costs to support test beam operations is an additional $2.9M. The desired HEP program is 20 weeks of either SEB or FEB or a combination of both. The incremental cost of 20 weeks of SEB operation is estimated to be $13.0M. The incremental cost of 20 weeks of FEB opera-tion is estimated to be $1.8M. If the AGS HEP fixed target program were to receive no funding in FY99, this would result in a reduction of force of 100 FTE out of the present staff of 280 FTE in the combined AGS and Tandem operations.

In addition, we provide below a table of incremental costs (in FY98$M) for various operating conditions and a base DNP support with and without test beam operation funding.

NP OPERATIONS COSTS FOR USE OF AGS AS THE RHIC INJECTOR

RHIC Injector Base	= $27.8M (156 FTE)
RHIC Test Beams (10 weeks)	= $ 2.9M (10 FTE)

HEP INCREMENTAL OPERATIONS COSTS FOR VARIOUS HEP SCENARIOS

NP Funding Scenario	Base + Test Beams	Base Only
DHEP Operations Scenario	FY96 $M	FY96 $M
SEB (10 Weeks)	9.8	14.2
SEB (20 Weeks)	13.0	17.4
SEB (30 Weeks)	16.0	20.4
FEB (10 Weeks)	1.5	2.7
FEB (20 Weeks)	1.8	3.4

In addition, these costs could be further ameliorated by means of possible future support for radio-biological research at the Booster, isotope production at the Linac and biological research supported by NASA. As noted above, planning has begun to incorporate the AGS and RHIC teams into a single and cost effective department about the time of completion of RHIC.

We suggest a transition funding scenario of AGS operations from high energy (KA) to nuclear physics (KB) in the budget tables. The transition is assumed to occur in FY99. In FY99 when RHIC begins operations, we expect the DHEP to support any incremental high energy physics fixed target operations. The budget table assumes a slow-spill, fixed target program of 20 weeks duration.

We emphasize to the reader that the reduction of AGS program target efforts must be linked to the future operations support of RHIC. RHIC operations critically depend upon the operations staff of the AGS. Without this staff the accelerator systems could not function. There must be a smooth transition of funding, personnel and DOE recognition of this fact. We believe both the HEP and NP offices are in agreement on this planning basis. We urge that both DOE program offices work with BNL to optimize both the present and the future physics programs.

High Energy Physics Research (KA-01)

The AGS provides a diverse array of high intensity, high quality beams for the broad high energy research program at BNL. The experiments that are done at the AGS are competitive with or complementary to the research being done at other accelerator laboratories, and some of the experiments are unique to BNL.

The centerpiece of the AGS research programs is a suite of experiments aimed at the search for and study of very rare K meson decay modes. These experiments are testing the limits of the Standard Model. Some searches for processes forbidden in the Standard Model have discovery potential for new gauge bosons with masses well beyond the direct reach of the LHC. The first round of these experiments has been completed, and construction of improved apparatus and beam lines to handle the increased flux of the AGS accelerator are nearing completion. Rare K meson decays can be expected to play an important role in the AGS program well into the late 1990's.

A new measurement of the muon g-2 factor will be a unique element of the high energy research program at BNL in the coming decade. The goal is a factor 20 improvement in the precision of g-2 over the last experiment completed at CERN. The BNL level of precision will allow a measurement of the hadronic contribution to g-2 and will provide a host of tests of possible physics beyond the Standard Model. A storage ring with an extremely precise and uniform magnetic field is being built for this experiment. It will be injected initially with pions and later with muons from the AGS/Booster.

Important new initiatives in hadron physics are getting started and will be producing unique results during the 1990's. Tests of perturbative QCD will be made in exclusive two-body scattering at 90 on a new detector based on the CLEO I solenoid. The long-term BNL program of searches for hadronic states outside the simplest quark model (such as quark-gluon hybrids and glueballs) will be continued in an upgraded MPS spectrometer. In addition, there are two experiments searching for a new state of strangeness enhanced matter (strangelets).

Other important elements of the BNL high energy research program over the next five years in-clude heavy ion physics (discussed in detail under Nuclear Physics Research below), polarized proton physics, nuclear "transparency", and searches for strange dibaryons.

BNL is making important contributions to high energy research at other laboratories and will con-tinue to do so in the coming years. The major current involvement is in the DØ experiment at Fermilab. BNL has built the uranium/liquid argon central calorimeter for this detector and has major responsibilities in the areas of data acquisition, computing and offline analysis. DØ has shown itself to be an excellent detector for the observation of the top quark in the Tevatron energy range during the Spring of 1995.

Participation in the Large Hadron Collider (LHC) Project at CERN is being discussed as a part of the future U.S. high energy physics program. LHC, will have a proton-proton total collision energy of 14 TeV. The participation in the physics program at LHC, however, will present the best possible strategy for the energy frontier physics program, particularly in the search for Higgs phenomena.

BNL was one of the most productive institutions in generic detector R&D for the SSC project. With the demise of the SSC, much of this work has been refocussed on the ATLAS detector for the Large Hadron Collider project proposed by CERN. Among the major areas BNL is involved in are liquid and crystal calorimetry, muon tracking systems, silicon drift detectors and electronics. These projects involve the study of fundamental properties of detection media, radiation damage, integrated readout electronics and new detector technologies. Because of these detector development resources, the availability of test beams and other aspects of laboratory infrastructure, BNL expects to be of service to the ongoing experimental physics program and to make substantial contributions to future high energy projects.

Brookhaven is expected to take a major role in the liquid calorimeter subsystem and a significant role in the muon subsystem in the ATLAS detector.

BNL's high energy theory group is extremely strong and well-matched to the experimental program, both locally and nationally. Strengths include precision tests of the Standard Model, electro-weak physics and lattice gauge theory. Growth over the next few years can be expected in the areas of high energy/nuclear overlap, which will be the focus of much of the research at RHIC.

Accelerator Collaboration with LHC (KA-03)

As a member of the U.S. Accelerator Collaboration Team, Brookhaven intends to play an impor-tant role in the U.S. Participation in LHC construction at CERN, applying fully BNL superconduct-ing magnet R&D and fabrication capability. This capability is the fruit of our strong DOE support since the 1960's. Technical areas and the mode of the collaboration are being developed by first coordinating among the U.S. laboratories (BNL, Fermilab, and LBL) and then with CERN. This collaboration, of course, is subject to an agreement between DOE and CERN.

The present plan for Brookhaven includes the following activities:

a) BNL will work on the dipoles for the intersection areas and on the dipoles in the rf sections.

b) BNL will work on testing of superconducting cables.

c) The superconductor measurement and characterization task and technical calculations and collaborative involvement in the magnet design will continue. In the areas of arc quadrupole and/or insertion dipole tasks, the effort to fabricate these magnets will begin.

Advanced Accelerator Design (KA-03)

The energy that can be reached in high energy accelerators is currently limited by their ever-increasing size. Circular hadron machines could be reduced in size if higher magnetic fields were available, but due to the limits in the strength of materials, large increases in magnetic fields seem impractical. The lengths of linear accelerators are governed by the accelerating gradients employed, and in this case there is no clear reason why several orders of magnitude increase in fields may not be obtainable. If accelerators at energies beyond those obtainable at the Large Hadron Collider (LHC) are to be obtained, such increases in the accelerating gradients must be developed. Brookhaven is playing a major role in attempting to achieve this goal. Efforts will be concentrated on the development of short wavelength accelerating structures. Under study are the accelerating field limits in such struc-tures and the development of power sources, such as lasers and advanced klystrons, to drive such structures. The group will, however, also consider other new ideas for obtaining high gradients. Theoretical work will continue at Brookhaven throughout the period.

The Accelerator Test Facility (ATF) is a User's Facility for accelerator and beam physicists, operated by the National Synchrotron Light Source and the BNL Center for Accelerator Physics (CAP). Twelve experiments, operated by users from universities, industry and national laboratories have been approved by the CAP Steering Committee. The high brightness electron beam of the ATF, produced by a laser-photocathode RF gun, make it an ideal site for R&D on laser acceleration of electrons and Free-Electron Lasers (FEL). In the past year the ATF has undergone a major upgrade in which a new injection system was installed that includes an emittance correction system and the photo-cathode laser has been rebuilt for better stability. The linac's energy is now 70 MeV.

Beamline #1 has an Inverse Cerenkov Laser Accelerator experiment (operated by STI Optronics, BNL and UCLA). This experiment has demonstrated about 4 MeV energy gain of electrons in 12 cm of laser accelerator using under 1 GW of the ATF's 20 GW CO_2 laser.

Beamline #2 supports an Inverse FEL experiment (BNL-Yale). Following this experiment, the NSLS high-gain harmonic-generation experiment will be located on beam line #2. The experiment is done in collaboration with Northrop - Grumman, which is providing many components of the undulator for the experiment. This experiment emulates the FEL physics of the NSLS approach to VUV FELs. This approach is based on single pass, seeded FEL amplifiers driven by Ti:sapphire lasers. The final stage of harmonic generation is being done in the FEL.

Beamline #3 is used for three FEL experiments (operated by the NSLS, MIT and Columbia University) centered on a micro-undulator FEL oscillator. The FEL experiment makes use of the short period of the undulator and the low emittance beam generated by the RF photocathode gun to operate at 500 nm with a 50 MeV electron beam. Since the ATF electron beam energy is currently at about 70 MeV, lasing at below 250 nm should be possible. A superconducting 68 period micro-undulator (with a period of 0.88 cm and 0.5 Tesla peak field at a gap of 0.44 cm) has been developed at the NSLS. An MIT group is carrying out a test of a pulsed micro-undulator. This undulator, which is currently installed on the beam line, has parameters that are very similar to those of the superferric undulator. Spontaneous emission has already been observed from this device and preparations are under way to get lasing in the very near future. A third user group is from Columbia University. They will be using the oscillator experiment for studies of spiking and optical guiding in FELs.

The electron gun of the ATF generates its high current, low emittance beam by irradiating a high-quantum-efficiency metal-cathode in the presence of very high intensity RF electric fields. The genera-tion and careful manipulation of such beams are areas of intense activity in accelerator physics, being the key to short wavelength FELs. Recently we have measured a record beam emittance (rms, normal-ized) of 1.1 pi mm mrad at a peak current of 60 amperes. Another record was set for quantum effi-ciency of a copper cathode at 0.05%. A new RF gun is currently under development at the ATF in collaboration with SLAC and UCLA. The objectives of this

collaboration are to develop a gun boasting low-cost, higher brightness as well as improved cathode replacement system.

Besides the above mentioned experiments, many others are taking place at the ATF. These include a Smith-Purcell radiation experiment (initiated by a Dartmouth group), photoinjector R&D and more. So far, seven graduate students have finished their thesis at the ATF and eight others are currently doing thesis research at this facility.

Studies on a High Energy, High Luminosity Muon-Muon Collider

Members of the Center for Accelerator Physics (CAP), supported by an LDRD grant, are actively involved in a study of possible future muon-muon colliders. The work is being done in collaboration with Berkeley, CEBAF and FNAL and is looking at a design that would give muon-muon collisions at a center of mass energy of 4 TeV, with a luminosity of $3\ 10^{34}$ cm^{-2} sec^{-1}. The design uses several new technologies, including the use of a current carrying target, large lithium lenses to capture pions, and ionization cooling of the muons.

Such a machine would have an energy reach significantly higher than that of either the Large Hadron Collider (LHC) that is now proposed at CERN, Switzerland, or the Next Linear Collider (NLC) as discussed by the Stanford Linear Collider (SLAC) and other groups. Yet such a muon-muon collider would be significantly smaller than these other machines. The muon-muon collider would, for instance, fit on the existing BNL or FNAL sites.

There are, however, many unanswered problems in such a machine. We cannot yet say if it is even possible. Some questions can be addressed theoretically and BNL will be requesting funds to expand the work that has already started. Other questions can only be answered by experimental studies. BNL will be requesting funds to perform two initial experiments:

a) An experiment to demonstrate the required production and capture of pions. A current is required in the target that will add to the beam heating there, and the lithium lenses are larger than any yet built. Off line studies would be performed first. Production distributions would then be measured using a low current proton beam, and finally heating and life studies would be done using the full AGS proton beam.

b) An experiment to demonstrate ionization cooling. Muon beam phase space density can be increased by allowing it to lose energy in a low Z material. The principle is simple, but the practice is hard because the muons must be very strongly focussed during the process to avoid emittance growth from Coulomb scattering. Such cooling has never been demonstrated. The experiment, using the method proposed for the machine, would both focus and reduce the beam energy in a long (circa. 2 m) current carrying lithium rod. The phase space density would be measured both before and after the rod.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
KA HIGH ENERGY PHYSICS								
Operating + 59.2	59.2	73.2	72.8	39.0	40.2	40.2	40.2	
Changes in Inventories	0.0	0.0	0.9	1.1	0.6	0.0	0.0	0.0
Capital Equipment	5.1	4.7	5.2	14.7	7.2	5.2	5.2	5.2
Construction (AIP)	2.5	2.0	2.0	2.7	2.7	2.7	2.7	2.7
Total Cost	66.8	65.9	81.3	91.3	49.5	48.1	48.1	48.1
Direct Personnel	324	324	348	352	252	252	252	252

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars
\+ FY1999 and FY2000 assumes 30-week fast extracted beam program. A 20-week slow beam program would increment this cost to 13.0M.

RESEARCH INITIATIVE

Switched Power High Electric Field Facility

A facility is planned to study the feasibility of producing ultra-high electric fields in the GeV/m region and in the 1-1000 ps time domain, and to investigate the use of these fields in applications such as high brightness injectors and high gradient accelerators.

Initially it is proposed to design and construct a full-size prototype Switched Power Gun (SPG). This switched power gun will generate very high fields by switching large photoemission currents in picoseconds, from a laser illuminated and high voltage precharged photocathode, situated at the perimeter of a radial line transformer. The EM pulse produced by the photocurrent is enhanced by propagation from the rim to the center of the transformer, where it can create fields exceeding 1 GeV/m, for times short enough to avoid breakdown in the vacuum. Such a gun can test the feasibility of producing: 1) GeV/m fields; 2) Particle beams about 100 times brighter than available now; 3) High gradient particle acceleration with over 10 times higher gradients than available now. Once the concepts underlying the SPG are proven, the system can be incorporated into a facility to study physical phenomena and material properties in the little known GeV/m field regime and to construct a high brightness injector.

Essential for such facility are a high voltage (up to 1 MV) laser triggered pulsing system of very low jitter and a high power UV laser system with multibeam sequential outputs. Development of these two systems by industry in consultation with BNL is currently being discussed, since they involve new technologies. The switched power gun will be developed, constructed and tested at BNL over a period of about three years with operation as a test facility thereafter. The project will be under the aegis of the Center for Accelerator Physics (CAP).

Switched Power High Electric Field Facility
RESOURCE PROJECTIONS

($ in Millions - B/A) (Fiscal Years)					
	1996	1997	1998	1999	2000
OPERATING	0.6	0.6	0.6	0.6	0.6
CAPITAL	0.7	0.7	0.7	0.7	0.6
TOTAL	1.3	1.3	1.3	1.3	1.2

RESEARCH INITIATIVE

High T_c Superconducting Magnets

The High Energy Physics community in the United States has been involved with speculation on the subject of future facilities. Two innovative proposals involve muon colliders to attain high energy lepton collisions and really large hadron colliders, where synchrotron light emission becomes a significant dynamical mechanism. We are proposing that the superconducting magnet needs of these two very different accelerator facilities have many common technical requirements, which are satisfied by the use of high $_cT$ superconducting materials.

We continue by reviewing the most recent results from high T_c materials research and point out that only recently have materials (yttrium-barium-copper-oxide) potentially capable of use in high field superconducting magnets become available. The possible use of these materials implies that consideration be given to tape wound magnets. We review the results obtained from a BNL tape wound magnet R&D program which took place ~20 years ago. We conclude with a three-part proposal; the fabrication of short (~1m) lengths of high T_c-J_c superconducting tape, the testing of this tape for suitability in superconducting magnets, and a conceptual design effort to investigate the options available for magnet design based on this material. This effort is estimated to take two year to complete at a funding level of ~$2.0M per year.

Brookhaven National Laboratory, with its interdisciplinary structure, is unique in its capabil-ities to both propose and conduct an R&D effort of this type in a highly efficient way. The scientific expertise and laboratory facilities are available in the Materials Science Division, to produce, in-house, short samples of superconducting tape of the kind needed for magnet fabri-cation. BNL also supports the only dedicated superconducting wire and cable testing facility in the world and is capable of performing all the necessary measurements on sample superconductors. In-house experience with tape wound magnet design and fabrication has been a feature of the BNL program over the years. BNL is active in the ongoing efforts focused towards the con-ceptual development of the machine issues in both programs and is uniquely placed to provide the intellectual interplay between accelerator and magnet design necessary for a successful R&D effort. Finally, BNL has maintained through the SSC and RHIC programs, one of the few laboratories in the world possessing the resources and facilities needed to contemplate a superconducting magnet program of this diverse scope in an efficient fashion. It is a very natural next step for BNL. Although it is tempting to widen the scope of the proposal to encompass other related applications, we have specifically chosen to focus our efforts towards accelerator magnets.

NUCLEAR PHYSICS (KB)

An important ingredient in the study of Nuclear Physics at Brookhaven is the availability of a variety of probes to study nuclear matter. These currently include protons, heavy ions, pions and kaons at the AGS, neutrons at the HFBR and high energy polarized gamma rays at the NSLS. These beams vary from strongly

to weakly interacting probes of the nucleus and thus allow a comprehensive picture of the nucleus to be obtained. Upon its completion in 1999 the Relativistic Heavy Ion Collider (RHIC) will be used to explore the nature of nuclear matter under extreme conditions of temperature and density and to search for a new state of matter, the Quark Gluon Plasma. This accelerator will have colliding gold ion beams of energy 100 GeV per nucleon per beam and a luminosity exceeding $10^{26} \cdot cm^{-2} \cdot sec^{-1}$. The RHIC machine will open new frontiers of physics research. By creating extended volumes of nuclear matter at extreme conditions of temperature and density - conditions which have not existed in the universe since the Big Bang - it will be possible to study the fundamental properties of matter in a state in which the primordial quarks and gluons are no longer confined as constituents of ordinary particles. Once achieved, this deconfined state of matter offers a whole new area of scientific study, the pursuit of which is of vital interest to nuclear physics, as well as elementary particle physics, and it will give essential new information regarding the early stages and subsequent evolution of our universe.

Medium Energy Nuclear Physics (KB-01)

The use of a variety of highly energetic projectiles to investigate the fundamental forces between hadrons and to search for new insights regarding nuclear structure from study of the properties of hypernuclei will continue to be a dominant theme during the plan period. Studies of interest to QCD such as a search for a "six quark" dibaryon system (e.g. the H particle) are under way.

The demise of the planned Canadian intense source of kaon beams at medium energies, KAON, has created a very significant interest in the nuclear and medium energy physics community for use of the AGS facilities. Should the physics proposals prove to be compelling, we expect that additional support would be needed to provide for acceleration and beam modifications as well as experiment operations time.

The long-term future of hypernuclear and K meson nuclear physics, based on increased current in the AGS afforded by the Booster, is being studied by BNL physicists and outside users.

The high energy (200-400 MeV) polarized gamma ray facility at the National Synchrotron Light Source X-Ray Ring provides a unique capability for the study of many phenomena of fundamental importance to nuclear physics. For example, among these will be the measurement of the polarizabilities of the proton and neutron from which it is possible to deduce the structure of these particles. A unique, polarized solid HD target is under construction as is a new laser, which will increase the maximum gamma ray energy.

Heavy Ion Nuclear Physics (KB-02)

The focus of the heavy ion program is Relativistic Heavy Ion Research. The search for extremely high density nuclear matter which will ultimately uncover the new phase of matter--the quark-gluon plasma--is being carried out at the AGS. Measurements of nuclear stopping and meson and strange

particle production and their correlations, are providing vital information on the "phase diagram" of nuclear matter and indicate the paths for production and demonstration of the quark-gluon plasma. Three major detector systems have now completed experiments with beams up to mass 197 and others are under way. In conjunction with the high energy program, an experimental program to search for strangeness enhanced matter, strangelets, has begun. The availability of higher energy beams in RHIC, will permit the complete exploration of this physics topic in later years. The effort to prepare experi-ments for RHIC is rapidly building up. An international community of some 600 scientists involving 6 U.S. National Laboratories, approximately 40 U.S. universities, and over 10 foreign countries, has begun building two large detectors for RHIC experiments. These detectors, called STAR and PHENIX, will be complemented by a number of smaller experiments, some of which (BRAHMS and PHOBOS) are well into the design stage, and some of which are yet to be proposed.

The detectors for RHIC are among the most complex and sophisticated collider detectors ever undertaken. Each will be capable of recording thousands of particle trajectories per collision event, utilizing hundreds of thousands of electronic readout channels per detector. The PHENIX detector is designed to study electrons, muons, photons and hadrons using state-of-the-art detector technology to provide broad sensitivity to these difficult signals in the high track density environment of nucleus-nucleus collisions in which the total collision energy is 20 TeV. The STAR detector, complementing PHENIX, involves the construction of what will be the world's largest time projection chamber to allow event-by-event reconstruction of thermodynamic observables such as temperature and entropy in these extraordinary events, as well as the measurement of "hard", point-like scattering of quarks and gluons in these collisions to produce high energy jets of final-state particles. The two smaller detectors, PHOBOS and BRAHMS, will provide the opportunity for more focused measurements, with specialized apparatus, for the early, exploratory phase of the RHIC experimental program. This complement of detectors will provide wide-ranging capability to explore new phenomena rich with potential for fundamental discoveries, and represents one of the most ambitious instrumentation efforts currently underway for nuclear physics experiments.

A proposal has been presented to DOE for additional experimental equipment to extend the physics capabilities of the major detectors STAR and PHENIX as the RHIC facility begins operation in FY99. Each of these detectors has been designed to have an ultimate physics reach substantially beyond that which can be achieved within the baseline construction funds of the RHIC project; i.e., each has begun construction with a minimal configuration to begin a research effort when RHIC turns on, and each has a clearly defined improvement path requiring additional detector equipment. The proposal requests a total of $33.7M (FY96$) over the 5 year period 1996-2000 to fund this equipment and, in addition, the capital funding (approx. $8M) to initiate the Off-line Computing Facility for RHIC.

The initial allotment of RHIC pre-operations funds began in FY95 and culminates with full opera-tions in the third quarter of FY99. There will be a shift in landlord responsibility at BNL from High Energy Physics to Nuclear Physics at that time. We expect that the Division of Nuclear Physics will support a modest slow-spill program at the AGS to supply the necessary test beam hours for RHIC detector support and development. We estimate that the cost would be $2.9M (FY99) yearly for 10 weeks of slow-spill test beam.

The RHIC Project is becoming the center stage of accelerator activity at BNL. There is a continuing need to support generic detector and accelerator R&D from the Nuclear Physics Program. Generic accelerator R&D would include the further development of super-conducting magnet and RF technology, study of the stochastic cooling of bunched heavy ion beams, and the development of an EBIS source to provide for RHIC 's more intense heavy ion beams (up to Uranium), than can be provided by the present injector. This activity is planned for initiation in FY96.

Increased operating funding is needed for operation of the Tandem-AGS heavy ion accelerator complex, detector development, and service to the user community for 12 operating weeks per year. Recently, as few as 4

weeks per year have been available for heavy ion running. There were improve-ments with runs of 6 weeks in FY95 and 12 weeks in FY96 now expected. The incremental funding that makes these runs possible also provided for the full research program shown in the budget plan.

Nuclear Theory (KB-03)

The nuclear theory group at BNL functions in a mode of strong interaction among its members, the particle and solid state theorists as well as with experimentalists at the Laboratory. A major effort has been made to add staff members to provide a focus for national efforts in the theory of Relativistic Heavy Ion Physics. A joint effort in this direction with the State University at Stony Brook is a modest step in trying to help solve this problem in a time of constrained budgets.

Nuclear Structure Physics (KB-04)

The study of nuclear structure using reactor neutrons in the U.S. has been reduced dramatically by the demise of the isotope separator, TRISTAN and the departure of the prime investigator. However, some studies of nuclear levels populated as a result of neutron capture continue to be carried out.

Solar Neutrino Experiment (KB04)

The aim of this area of research is to gain an understanding of the "solar neutrino problem", name-ly that the well-known chlorine and Kamiokande detectors measure fluxes of neutrinos from the sun that are less than one half of the theoretically expected values. Current explanations of these discrepancies require that either the solar theory is incomplete or that new neutrino properties, such as finite mass and neutrino oscillations, must be invoked.

After years of planning and construction, the GALLEX project began its search for a solar-neutrino signal at the Gran Sasso National Laboratory in Italy in May, 1991. Scientists from BNL and several European laboratories are collaborating on the project, with primary responsibility for chemical aspects residing with BNL. GALLEX uses a new radiochemical neutrino detector made of thirty tons of gallium (as gallium chloride solution); the isotope ^{71}Ga is sensitive mainly to the low-energy neutrinos from the primary p-p reaction in the sun.

Important new results were obtained by GALLEX in CY 1995. The latest cumulative solar-neutrino result from 39 solar exposures is(77.1 $^{9.6}$)

$_{10.1}$ SNU, which is only about 60% of theoretical predictions.

This result can be interpreted as being the sum of the full (*pp+pp*) and about 50% (Kamiokande's result) of the ^{8}B signals, with little room left for ^{7}Be neutrinos. This scenario cannot be explained by any solar model, where ^{7}Be is the precursor of ^{8}B in the sun. However, the MSW mechanism can account for these results, in terms of energy dependent oscillations in the sun
between neutrino states with non-zero mass. If true, this conclusion leads to new physics beyond the standard electroweak model. A final result from the test of the GALLEX experiment with a Mega-Curie source of ^{51}Cr was obtained: the updated ratio of detected to expected neutrinos was 0.97 0.11. Since all of the neutrinos incident on the gallium target were detected in this "calibration", it follows that the measured 40% deficit in the GALLEX solar neutrino signal cannot be attributed to experimental artifacts.

A significant new development occurred in early 1996, when the BNL neutrino group was invited to join a second major collaboration, the Sudbury Neutrino Observatory (SNO). Their initial focus is in the areas of the chemistry and radiopurity of the D_2O and H_2O water systems. Their active parti-cipation in both neutrino projects will continue through the next year, when GALLEX is expected to come to an end and SNO is scheduled to begin.

Nuclear Sciences (KB-04)

This program supports the ongoing efforts of the National Nuclear Data Center (NNDC). The NNDC is responsible for data compilation, evaluation, and information services for neutron, charged particle, and nuclear structure physics. The NNDC maintain bibliographic, experimental, and eval-uated data files for these areas of physics; provides data services to basic and applied scientists in the United States and Canada; and is the focal point for data exchange with other countries. In particular, the NNDC is responsible for the development, maintenance, coordination, promotion, and distribution of the reference nuclear data base, the Evaluated Nuclear Data File/B (ENDF/B) and the Evaluated Nuclear Structure Data File (ENSDF). New initiatives in nuclear data for astrophysics and heavy ion reaction data areas are being undertaken.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
KB NUCLEAR ENERGY PHYSICS								
Operating	24.7	28.2	32.9	42.4	120.7	118.8	118.8	118.8
Capital Equipment	3.8	5.6	9.6	11.6	13.4	20.8	19.0	19.0
Construction (AIP)	1.3	1.3	1.3	3.3	3.3	3.3	3.3	3.3
Construction (RHIC)(a)	70.0	65.0	65.0	59.4	15.7	0.0	0.0	0.0
Total Construction	71.3	66.3	66.3	62.7	19.0	3.3	3.3	3.3
Total Cost	99.8	100.1	108.8	116.7	153.1	142.9	141.1	141.1
Direct Personnel	521	506	486	467	494	526	527	527

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars
(a) Funded

BASIC ENERGY SCIENCES (KC)

Basic Energy Science programs at Brookhaven include major efforts in Materials and Chemical Sciences and smaller but productive, visible and far reaching at the Laboratory. There are several major initiatives in this area that are aimed at keeping our two major BES user facilities, the HFBR and the NSLS, frontier machines capable of serving an increasing community of academic and industrial users. There is a critical need to provide the neutron scattering community in the United States with reactor based cold neutron capabilities with intensities comparable with those available in Europe. The HFBR is proposing to replace the reactor vessel and optimize the existing cold source so as to give the United States a state-of-the-art neutron facility for the 21st century. At the same time the DOE plans to build a next generation spallation neutron source, and the principle R&D effort will involve the design of the target. The AGS is unique in being able to provide proton pulses with peak powers that match those needed for the new spallation source, and BNL proposes to build a target and beamline test stand for this R&D effort. The NSLS continues to request funds to upgrade the instrumentation so as to take advantage of recent development in both beamline and accelerator design. Finally, the NSLS is part of a collaboration nationwide to develop free electron lasers. A continuing initiative is to develop an FEL operating in the ultra-violet which will provide a high brightness, short pulse source. This FEL will offer new opportunities to study chemical reactions in real time in an energy range which is not covered by existing synchrotrons or lasers.

High Flux Beam Reactor. The High Flux Beam Reactor (HFBR) is one of the nation's major centers for neutron investigations in solid state and nuclear physics, chemistry and structural biology. Designed specifically to provide intense external beams of thermal and sub-thermal neutrons for experimental purposes, it produces a thermal neutron flux of $1x10^{15}$ neutrons/cm^2-sec when operating at 60 megawatts power. Its nine ports serve 15 experimental facilities, most of which are operated by Participating Research Teams consisting of Brookhaven scientists and regular users of the reactor from other government, industrial and universities laboratories. Major programs currently exist in the study of the decay of neutron-rich nuclei, protein and chemical crystallography and the study of excitations in solids, particularly in relation to superconductivity and magnetic and structural phase transformations. Seven vertical thimbles provide a variety of neutron energies for sample irradiation and support a major Positron Physics Facility.

Over the past few years, three new instruments have been constructed and new Participating Research Teams have been formed to manage and maintain them. This increase in capability has resulted in corresponding increases in the size of the user program. We have just completed a dedicated neutron "optical bench," a national resource for the testing of new neutron devices and measurement techniques and are seeking a modest funding increase to support this effort. (See Research Initiative--Neutron Optics). Next year, a thermal neutron guide utilizing advances in neutron reflective coatings will be completed, which will allow five instruments to share a beamport presently serving two instruments, further increasing the scientific capabilities of the HFBR. With continued DOE support we intend to extend the upgrade of the scientific instrumentation over the entire 5 year period. These upgrade activities have been given high priority by a BESAC subpanel looking at the future of U.S. neutron scattering. We are also working with DOE nuclear regulators toward the twin goals of reducing reactor operating expenses and increasing the operating power level. We will continue to explore the replacement of the HFBR reactor vessel, together with a world class guide hall and an improved cold neutron moderator. (See Research Initiative--HFBR Upgrade).

National Synchrotron Light Source. The NSLS, from its inception, has been at the forefront of both the production and the utilization of synchrotron radiation. Within the next few years there will be four DOE user facilities serving the U.S. synchrotron community, and the NSLS is evolving to meet the needs of the community. The NSLS has steadily been increasing its flux, as a function of time and is comparable to the other light sources. The majority of present synchrotron based experiments are not source limited. However, all experiments can benefit from improved source stability and improved beamline optics and detectors. The synchrotron community continues to expand, but more must be done to increase the breadth and depth of the user base. The key components of this effort will be schools and workshops that will provide both current and new users with the state of the art tools to fully utilize the radiation available; presentations at scientific meetings of important results where synchrotron radiation has been crucial; individual outreach to lab based users of photons who are unfamiliar with the potential of synchrotron radiation for their programmatic needs.

It is equally important for the Participating Research Team (PRT) system at the NSLS to evolve. The NSLS pioneered the concept of the PRT, and they provided the intellectual and financial resources to rapidly establish a vibrant research community at the NSLS. Most other synchrotron facilities worldwide have emphasized facility built and operated beamlines, and with the general decline in research funding, the NSLS management believes that the most effective mode of operation will be one in which we take the best of both types of systems. The strong PRTs should be encouraged to continue to make maximum use of the facility, but where appropriate the NSLS should become a PRT member, and the formation of "super PRTs" or confederations of PRTs will be encouraged. This will lead to an overall increase in efficiency of operation and to a more cost effective operation. First, beamline operation can be streamlined through standardization. Second, this will lead to common support mechanisms, and third it will provide a means through which overall upgrades of beamlines can be accomplished as new technology develops. Initial confederations will be built around the areas of structural biology, x-ray absorption spectroscopy and powder diffraction.

The NSLS X-ray and VUV storage rings operated through the entire 1994 fiscal year providing reliable, high quality photon beams for the experimental programs. The facility runs 24 hours per day, 7 days per week with occasional scheduled downtime for maintenance and machine studies. In FY94, beam was provided to the users 5127 hours and 5388 hours during the year on the X-ray ring and VUV ring respectively. Over 2200 users performed experiments during FY94. Over 1195 experiments were performed and 545 papers based in part on work done at the NSLS were published.

With the completion of the additions to the NSLS building, an additional 12,400 square feet of floor space will become available to the user community. The NSLS has now reached its goal of providing a set-up laboratory, adjacent to the experimental floor, to each of the PRTs. In all there are 52 rooms of which 42 are assigned to PRTs and the remainder are either general purpose laboratories, set-up labs for general users, or short term storage space.

The NSLS has a long tradition in developing photon-based techniques to probe various aspects of the atomic and electronic structure of matter. Two areas of these developments are the study of magnetism and infrared microspectroscopy. Soft-x-ray magnetic circular dichroism (MCD) is becoming a routine spectroscopic tool in magnetism research and magnetic materials development. Recently, an elliptical polarized wiggler, built by a collaboration between the Advanced Photon Source, the Institute of Nuclear Physics, and the NSLS, was installed in the X13 straight section. It delivers circularly polarized soft-x-rays on axis, and the helicity of the photons can be switched up to 100 Hz. The unique capability of this new device should significantly reduce the systematic error usually encountered in performing MCD measurements on hard magnets and paramagnetic samples where a large magnetic field is needed to magnetize the sample. In a related experiment, a vacuum compatible reflectometer was developed to extend the study of magneto-optical Kerr effects to soft-x-ray region, from few hundred eV to 3 KeV. This photon energy range is particularly important because it includes both the $L_{2,3}$ absorption edges of the 3d transition elements and the $M_{4,5}$ absorption edges of the rare earth elements, where the largest resonant enhancement of the magnetic scattering amplitudes are observed. To fully realize the potential of this new technique in the study of magnetic surfaces, thin films, and multilayers, we plan to improve the vacuum of the instrument to allow in-situ sample preparation and the temperature control of the sample, and to increase the magnetic field strength that can be applied to the sample. The prototype small gap undulator (PSGU) is operational and an in vacuum undulator device (IVUN) is under construction in collaboration with Spring-8 in Japan.

An infrared microspectroscopy facility using a modified Spectra-Tech IRs scanning microspectrometer was built in the late spring of 1994. The microscope is owned by the Northrop Grumman Advanced Technology and Development Center and is used for evaluation of semi-conductors and devices as well as for studies of some of the new composite structures used in the aerospace industry. The development on U2 described above will be extended to another full infrared beamline to be constructed on U12 and one on U10. Both front ends were installed in FY96.

On the VUV ring, the upgrade of the U7B beam line from a toroidal grating monochromator (TGM) to an spherical grating monochromator (SGM) is completed. Dow and the National Institute of Science and Technology (NIST) have built a second experimental chamber to supplement the end station funded by DOE Chemical Sciences and active time shared programs underway. A high reso-lution undulator based photoemission beamline operating in the 5-30eV range is under construction on U13. The monochromator has been ordered, and the endstation is being developed on U11 and will move to U13 in the fall. We have funded an upgrade of the U5 spin polarized photœmission beam line to offset equipment to be taken by the University of Texas to CAMD, the synchrotron facility in Louisiana. The magnetic circular dichroism beam line U4B has been replaced.

It is our expectation that by the end of next year the VUV ring will have the following complement of beamlines: 3 infrared beam lines which are unique in the world and specialize in surface vibrations, high pressure

research and spectromicroscopy; 4 SGM beamlines (2 undulator and 2 bending magnet) which are used for MCD, chemical spectroscopy and spin polarized photoemission; 1 undulator based low energy, high resolution, photoemission beam line; 1 undulator based coherent optics development line; 3 TGM beam lines with reasonable resolution; 2 extended range grasshoppers (ERGs) used by industry for catalyst development; one circular dichroism beamline for biological research, and one plane grating monochromator (PGM) beamline for training students. This will provide a broad range of capabilities and represents a contraction from the original 26 beam lines to a set of 15 fully utilized, productive beam lines.

Our plans for the x-ray ring are less well developed because they depend in part on how the user community will redistribute when the APS becomes fully operational. By the summer there will be 5 biology beam lines which are all oversubscribed. We are working to develop a 6th line. The biologists are working to standardize the software as much as possible and to develop a coherent review and beamtime assignment process so as to maximize the utilization of these scarce resources. After a slow beginning, we can say with confidence that the structural biology program is thriving based on a series of important structures recently published in Cell, Nature, and Science.

There are already 2 oversubscribed beam lines which are devoted completely to powder diffraction. With the capital funding from DOE Materials Sciences we will build a third powder line. It is our hope to develop a rapid turn around powder diffraction capability which will cover the whole range from simple indexing and phase identification to abinitio structure determinations.

The third area where there are a core of at least 6 beam lines is absorption spectroscopy. Again we hope to stimulate the formation of a confederation which can standardize and share resources so as to develop an expanded capability. The NSLS is the catalyst and is providing resources, optics and user support, in this area. There is a small CRADA between NSLS and DuPont to standardize speciation studies of lead contaminated waste sites.

A number of projects to improve the accelerators and to test new concepts in insertion devices have made notable gains during the year and they include:

1) The small gap undulator was installed and tested in the X13 straight section. Operation was achieved at the hardware limited vertical electron beam aperture of 3.8mm, without any decrease in electron beam lifetime. The device was removed in December 1994 for modifications to allow operation at electron beam apertures down to 2mm. It was reinstalled in the Spring of 1995 and is operated routinely at a gap of 3mm. The successful operation of this R&D undulator has important implications for future insertion devices at both second and third generation facilities. The next phase of this program, the in vacuum undulator (IVUN) will be installed in FY97.

2) The polarized wiggler, which is an accelerator R&D project done in collaboration with the APS and BINP, Novosibirsk, was installed in the X13 straight section in December 1994. It is comprised of a hybrid permanent magnet vertical wiggler and an electromagnet horizontal wiggler capable of AC operation. This makes possible a source with a time-dependent circular polarization. The device was commissioned and run in routine operations at 2 Hz, while maintaining the required orbit stability. Commissioning to 100 Hz in underway.

3) Construction of two new all copper RF cavities to replace the existing (and aging) RF cavities in the x-ray ring is beginning. The present cavities have vacuum to water seals which give rise to a potential severe disruption in operations.

4) In Spring 1995, we increased the operating current in the x-ray ring during machine studies at 2.584 GeV to 300 mA (from 250 mA), to be followed by an expected increase to 350 mA and then to 440 mA. Together with an already achieved reduction of the vertical emittance by a factor of six, this will yield an increase in

brightness by a factor of ten. User operations of these currents await heat load studies on key components, such as Be windows and crotches. Studies are under-way to reduce the horizontal emittance from 110 nm to 50 nm.

5) In Spring 1995, we also increased the operating energy of the VUV ring from 750 MeV to 800 MeV. Tests have shown this gives a significant increase in the electron beam lifetime. This lifetime increase is additional to that recently obtained by powering the fourth harmonic bunch lengthening cavity.

6) The upgrade of the injection system is nearing completion and the increase in performance and reliability already obtained has been dramatic. A further increase in charge rate by a factor of two is expected when the booster repetition rate is increase from 1 to 2 Hz, our immediate goal is 1.2 Hz.

7) The new control system has greatly improved operations, reducing downtime and simplifying trouble shooting. The capability for logging system history over long and short time scales has been extremely useful. The availability of fast communications has allowed the development of many important application programs.

8) The upgrade of the NSLS chilled water system was completed during the December 1994 shutdown. This is an ARAM and GPP project which hooked up to the BNL central chilled water facility and provided for both improved measurement and control of the water in the different systems which cool the accelerators. These improvements have increased the stability of the electron and photon beams on both the x-ray and VUV rings.

In the past few years we have assembled a magnet group for developing new wigglers and undulators. As discussed above, three examples in this area are the very successful small gap undulator project, the polarized wiggler project, and the IVUN to be installed in the x-ray ring. The new superconducting wiggler to replace the prototype which is on beamline X17 has been ordered and will be installed in 1997.

The NSLS has been fairly successful in assembling the major components for a "NSLS Source Development Laboratory" to develop 4th generation sources and to study for example production of coherent radiation from short bunch operation of storage rings. We have the following major components in place: 230MeV electron linac, 10 Meter wiggler, 200MeV compact storage ring, and the building (729) in which to house the project. A team has been assembled to spearhead the building of a free electron laser which will operate in the UV. With LDRD and NSLS funds as seeds we hope to begin building a high brightness gun and compression sections as the next two necessary components. We have submitted an FWP for funding by DOE to finish this important demonstration experiment. Each of the SDL sources has experiments planned to utilize the radiation they produce and hence, addresses the recommendations of the DOE commissioned NRC Panel report on FELs to provide a sound technical basis for decisions regarding new facility development into the next century.

The ATF program in RF guns is recognized internationally as cutting edge R&D, as exemplified by its recent measurement of slice emittance in a 10 ps electron bunch. The generation and careful mani-pulation of such beams is an area of intense activity in accelerator physics, being the key to X-Ray FELs.

A High-Gain Harmonic-Generation FEL experiment is in advanced stages of preparation. It constitutes a Proof-of-Principle for the generation of Deep-UV [DUV] and X-Ray FELs based on single pass, sub-harmonically seeded FEL amplifiers driven by Ti:sapphire lasers. The resulting radiation from such an FEL retains the pulse length, as well as the wavelength and bandwidth stability of the seed laser. These are important considerations for the end user of the FEL.

Next Generation Pulsed Spallation Neutron Source. In 1992, a subpanel of Basic Energy Sciences Advisory Committee issued a study entitled, "Neutron Sources for America's Future." A principal recommendation of this study called for conceptual design studies for a next generation pulsed spallation neutron source (PSNS). With the cancellation of the Advanced Neutron Source, DOE announced its intention of a design study for a

spallation source, with Oak Ridge designated as the lead laboratory. Brookhaven National Laboratory, with extensive experience in accelerator and high power density target design, neutron scattering techniques, as well as the construction, operation and use of large national user facilities, has considerable expertise to contribute to a national design effort.

Unlike a reactor which produces a continuous flux of neutrons by a chain reaction in a core of fissionable fuel, a PSNS produces pulses of neutrons by the impact of energetic (1 GeV) protons on a heavy metal target. A PSNS has some advantage over reactor based sources of higher average flux. The subpanel study documents important scientific and technological applications that can be addressed with such a source, as for example, for studies that require an extensive mapping of energy and/or momentum transfer. By contrast reactor based sources are often more efficient at zeroing in on definite regions of energy and momentum to answer specific questions.

Over the past year, an interdepartmental BNL team has considered various design options for a next generation PSNS capable of handling up to 5 MW average proton beam power. We have considered trade-offs between various accelerator, target, moderator and user instrumentation options. We have settled on a design using a 0.6 GeV, 60 Hz linear accelerator in tandem with two fast cycling 3.6 GeV booster synchrotrons operating at 30 Hz. Each booster ring would feed an independent target station, one for "cold" neutron operation at 10 Hz, the other for thermal neutron operation at 50 Hz. Our design differs from existing conventional ones primarily in two respects--a higher proton beam energy and the use of a compact particle bed of heavy metal spheres as a target. A further assessment of the possibility of phased construction, starting with 1 MW and leading ultimately to 5 MW as experience in target technology accumulates, will be explored in our ongoing studies. We have had constructive discussions with ORNL scientiests and are ready to collaborate in an inter-laboratory study leading to a site independent reference design of a PSNS. We intend to participate in an interlaboratory study leading to a site independent reference design of a PSNS.

Materials Sciences (KC-02)

This program will continue to carry out broadly based research into the bulk and surface properties of condensed matter. Much of the experimental work is carried out at two of the Laboratory's major facilities, the HFBR and the NSLS. A strong theoretical component of this program is crucial to understanding and fully utilizing the results of the experimental programs, as well as providing new ideas and concepts for state-of-the-art experiments. A major component of the theory program is centered on the use of supercomputers for the study of the metallic properties of various alloys. A substantial part of the experimental program is concerned with novel instrumentation. A new beam line devoted to the testing of advanced neutron optics and to novel approaches to neutron instrumentation is under construction. With modest incremental funding this facility could serve as a focus for a nation-wide effort to develop instrumentation concepts for a next-generation neutron source. A state-of-the-art neutron powder diffractometer is under development, as well as new sources for high intensity positron beams. New beam lines are being constructed for experiments on both the x-ray and VUV rings at the NSLS. These facilities will allow studies of the structure of liquids and liquid surfaces, magnetic properties of surfaces, as well as the chemical and structural properties of surfaces and interfaces over a wide range of temperatures. Other programs have already been developed in response to the new initiative in Synthesis and Processing. These programs include theoretical work on interfaces, high pressure synthesis of nitrides, and studies of the use of synchrotron radiation and cryogenic techniques to make BN and other insulating coatings. Strong state-of-the-art laboratory facilities are also maintained for a broad based program and include unique facilities for both positron and inverse photoemission studies. This experimental program makes it possible for BNL scientists and outside users to address a new range of problems in condensed matter physics and enhance the impact of the major facilities on materials research. During the past year all the groups in the Solid State physics program have continued strong outside collaborations, which have been centered at the facilities.

In the materials and applied physics areas, research will continue to emphasize fundamental studies of the relationship between the structure and properties of materials. Mechanisms of metal-environment interactions, focussing on a fundamental understanding of the initiation and propagation of localized corrosion in metals and alloys is an economically important topic. Surface coating and reaction products inducing passive oxides on metals offer approaches for improving corrosion resistance. Surface modified materials and buried interfaces are scientifically interesting while at the same time have practical applications. Electroresponsive polymers and high T_c superconductors are rapidly moving from the laboratory to the marketplace. In the latter area, the primary focus is on the structure and properties of the high-critical-temperature superconducting oxides, including facilities for fabricating thin film specimens and high quality single crystals of these materials. Understanding of the nature of the grain boundary as a weak link in a fabricated high T_c device is an important research topic. This research is both experimental and theoretical in nature, and the powerful analytical tools provided by the HFBR, the NSLS, and the low-energy particle accelerators are utilized, as well as the traditional methods of electron microscopy, x-ray scattering, etc. A new program, Microstructure of Materials, is being proposed to utilize and further develop the state-of-the-art techniques of transmission electron microscopy (TEM) to study crystal structures, structural defects, and interfaces in crystalline materials. The Structure-Sensitive Properties of Advanced Permanent Magnet Materials: Experiment and Theory is another new program recently funded in the BES/DMS New Initiative Competition, with a goal to achieve a detailed understanding of how crystal-lattice defects affect the magnetic properties of intermetallic compounds. This program is also part of the Synthesis and Processing Center of Excellence thrust on hard magnetic materials. Other Center-related activities include research on photovoltaic materials, conducting polymers, amorphous metals, and surface hardening. These programs include industry, universities and another national laboratory. In the Materials Chemistry area, research continues towards developing a comprehensive description of the structure and dynamics of atomic and molecular films adsorbed on surfaces. Monolayer and multilayer films adsorbed on crystalline powders and convective flows in liquid helium mixtures are studied using neutron and/or x-ray scattering techniques at the HFBR and the NSLS. Preliminary investigations of simple, surface-mediated chemical reactions have begun. Outside collaborations with universities and industrial laboratories continue to enhance these efforts.

Work with focuses on the synthesis and characterization of novel framework materials has begun. Such materials have applications in the area of heterogeneous catalysis. The effort will be a collaboration between BNL, SUNY Stony Brook and Dupont. Characterization tools available at BNL, including high resolution x-ray and neutron scattering at the NSLS and the HFBR will be employed. The overall aim is to develop vital structure-property relationships in this class of materials.

Brookhaven has responded to the Federal Program in "Advanced Materials and Processing" by developing a joint program involving the various areas funded by the Division of Materials Sciences in the Office of Basic Energy Sciences. A new program at BNL on the structure-sensitive properties of advanced magnetic materials, which is a component of the DOE Center for Excellence for the Syn-thesis and Processing of Advanced Materials, was recently funded in the BES/DMS New Initiative Competition for FY96. Work will be continued on existing Synthesis and Processing programs on two focus areas on polymerized films in the microstructured engineering with polymers and on processing for surface hardness examining the submicroscopic defects.

The program on magnetic materials, which utilizes both theoretical and experimental methods, including characterization using x-rays at the NSLS and neutrons at the HFBR, will emphasize the relationship of defects and microstructure to the properties of permanent magnets.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
KC-02 MATERIALS SCIENCES								
Operating (Research)	10.4	10.9	14.8	14.6	14.6	14.6	14.6	14.6
NSLS Operations	16.3	18.2	21.7	22.4	22.4	22.4	22.4	22.4
HFBR Operations	20.8	22.4	24.5	25.4	25.4	25.4	25.4	25.4
Total Operating	47.5	51.5	61.0	62.4	62.4	62.4	62.4	62.4
Changes in Inventories	0.0	0.0	0.0	1.9	0.2	0.2	0.2	0.2
Capital Equipment	1.3	4.5	4.1	4.1	4.1	4.1	4.1	4.1
Construction								
ARAM	2.4	5.6	5.1	6.3	6.3	6.3	6.3	6.3
HFBR Facilities Upgrade(c1)	--	--	--	15.0	--	--	--	--
NSLS Phase-III Upgrade(b)	--	--	--	--	7.6	15.5	4.8	--
Total Construction	2.4	5.6	5.1	21.3	13.9	21.8	11.1	6.3
Total Cost	51.2	61.6	70.2	89.7	80.6	88.5	77.8	73.0
Direct Personnel	292	288	308	314	314	314	314	314

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars
(b) Validated
(c1) Proposed/out-year funding to be determined.

RESEARCH INITIATIVE

Neutron Optics

Several high-level studies have called attention to the fact that the U.S., which once led the world, has fallen behind Western Europe in neutron scattering research. One of the contributing factors is the lack of dedicated facilities suitable for developing instrumentation on a full-time basis, and the commitment and resources necessary to carry out such a program. To help remedy this situation a Neutron Optics initiative has been developed. The objectives of the program are three-fold: 1) to establish experimental facilities at the High Flux Beam Reactor where neutron reflectivity techniques can be applied to the study of condensed matter; 2) to explore new ways to employ optical methods in neutron spectroscopy; and 3) to improve the performance of neutron optical elements such as guides, polarizers, monochromators and beam-focussing elements, and to evaluate their use in various pulsed and steady-state applications. The focus of the program will be a flexible dedicated neutron optics "test-bench" located on a HFBR cold neutron beam line. This facility, together with a modest in-house staff, will be made available to qualified researchers on a peer reviewed basis. This initiative will provide a timely impetus for the design of new instrumentation for the proposed upgrade of the HFBR.

Neutron Optics
RESOURCE PROJECTIONS
($ In Millions - B/A)
(Fiscal Years)

		1996	1997	1998	1999	2000	2001
OPERATING		0.3	0.3	0.3	0.3	0.3	0.3
CAPITAL		0.1	0.1	0.1	0.1	0.1	0.1
TOTAL	0.4	0.4	0.4	0.4	0.4	0.4	

RESEARCH INITIATIVE

Brookhaven Synthesis and Processing

Brookhaven has responded to the Federal Program in "Advanced Materials and Processing" by developing a joint program involving the various areas funded by the Division of Materials Sciences in the Office of Basic Energy Sciences. A proposal has been submitted for several work areas, with strong emphasis on projected programs on the properties and ion transport through nanopores, advanced magnetic materials, and ion transport in zeolites. Work will be continued on existing Synthesis and Processing programs on plasma polymerized films, high pressure synthesis of nitrides, and materials processing using synchrotron radiation.

The program on magnetic materials will emphasize the relationship of defects and micro-structure to the properties of permanent magnets. The program on the properties of nanopores will emphasize using novel methods involving a Scanning Transmission Electron Microscope to make pores down to the 1 nm regime, and then measuring ion currents through such pores.

In addition, a new Materials Characterization Program, the aim of which is to provide assistance in x-ray and neutron scattering techniques for solid state chemists and other materials scientists untrained in the use of these tools, is proposed for the HFBR and NSLS.

Brookhaven Synthesis and Processing
RESOURCE PROJECTIONS
($ In Millions in Budget Authority)
(Fiscal Years)

	1996	1997	1998	1999	2000
OPERATING	1.4	1.4	1.4	1.4	1.4
CAPITAL EQUIPMENT	0.2	0.2	0.2	0.2	0.2
TOTAL	1.6	1.6	1.6	1.6	1.6

RESEARCH INITIATIVE

Microstructure of Materials

A new program, focusing on the microstructure of materials, is proposed to utilize and further develop the state-of-the-art techniques of transmission electron microscopy (TEM) to study crystal structures, structural defects, and interfaces in crystalline materials.

Microstructure of Materials
RESOURCE PROJECTIONS
($ In Millions in Budget Authority)
(Fiscal Years)

	1996	1997	1998	1999	2000
OPERATING	0.3	0.3	0.3	0.3	0.3
CAPITAL EQUIPMENT	0.8	--	--	--	--
TOTAL	1.1	0.3	0.3	0.3	0.3

Chemical Sciences (KC-03)

A broad range of chemical phenomena in the gas, liquid and solid phases continues to be studied. Many of the studies exploit BNL's unique facilities; others are interdisciplinary and involve several research groups.

Improved understanding of chemical catalysis is pursued through elucidation of the fundamental properties of molecules, surfaces, and their reactions that are critical to catalysis. Reactivity-structure correlations are a key aspect of these studies. Complexities stemming from the inherent multi-component aspects of heterogeneous catalysis are explored through both ultra-high-vacuum surface science investigations of well-defined model systems and powder diffraction and x-ray absorption studies of more "real-world" systems. Emphases include understanding the effects of catalyst modifiers at a molecular level and on rationalizing the distinctive behaviors of bimetallic surfaces that simulate important industrial bimetallic catalysts. X-ray and ultraviolet photoelectron spectroscopies at the NSLS are essential to this work. In a new effort, STM studies are leading to methods for preparing tailored bimetallic surfaces where the growth of a second metal is controlled by manipulation of its mobility on the modified support. Some of the first *in situ*, time-resolved studies of the formation and transformations of zeolitic materials, supported metals, and metal oxides under catalytic reaction conditions are now possible using the improved x-ray diffraction/absorption facility at the X7B beamline at the NSLS. Further upgrades of experimental, instrumental and computational capabilities of this beamline are being sought. Homogeneous catalysis efforts center around transition metal hydride complexes and sustainable feedstocks. Reactivity studies of metal hydrides elucidate the factors that determine the rates and mechanisms of M-H bond cleavage reactions that are central to the participation of metal hydrides and molecular hydrogen complexes in catalysis. Understanding of hydride chemical reactivity and bonding is further enhanced by the uniquely accurate structural data for these complexes obtained from neutron diffraction studies at the HFBR. A priority is the development of new types of catalytic reactions, especially those designed to yield non-oxidative approaches to oxygenated organics from sustainable resources, such as biomass and carbon dioxide; novel aspects of metal-carbohydrate chemistry are explored, with a focus on selective complexation, reactivity studies, and catalytic conversions.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
KC-03 CHEMICAL SCIENCES								
Operating (Research)	9.8	9.6	11.1	11.3	11.3	11.3	11.3	11.3
NSLS Operations	7.1	7.9	9.3	9.6	9.6	9.6	9.6	9.6
Total Operating	16.9	17.5	20.4	20.9	20.9	20.9	20.9	20.9
Changes in Inventories	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Construction								
NSLS DUV-FEL Facility(c)	--	--	--	--	--	13.7	17.3	15.9
Capital Equipment	2.3	1.9	3.2	4.0	4.0	4.0	4.0	4.0
Total Cost 19.2	19.4	23.8	24.9	24.9	38.6	42.2	40.8	
Direct Personnel	112	94	100	104	104	104	104	104

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
**Constant FY1998 dollars
(c)Proposed

RESEARCH INITIATIVE

BNL Center for In Situ Catalysis and Advanced Materials Studies (CISCAMS)

The feasibility of conducting sub-minute, time-resolved x-ray diffraction experiments under a wide variety of sample conditions has recently been established by studies at the National Synchrotron Light Source (NSLS) and elsewhere, promising important advances in the study of dynamic chemical systems, including heterogeneous catalysis and advanced materials syntheses. These new capabilities result from combining the high intensity of synchrotron radiation with rapid new parallel data-collection devices. Advances in parallel data acquisition techniques have also made possible new neutron scattering and diffraction experiments at the High Flux Beam Reactor (HFBR). It is significant to note that BNL is currently the only United States institution having both neutron and synchrotron facilities available at the same site. Based on this and DOE's expressed interest in new and upgraded research capabilities at its major Facilities, the BNL Chemistry Department has submitted a plan to develop an integrated, state-of-the-art national Center for *In Situ* Catalysis and Advanced Materials Studies (CISCAMS), to be co-located at the NSLS and the HFBR. This multi-user Center will have a significant impact on problems of both scientific and technological importance. The power of CISCAMS will be augmented by the ready availability at BNL of other advanced reactivity and structural probes, including a scanning transmission electron microscope (STEM) and scanning probe microscopes (STM and AFM), as well as other synchrotron-based probes at the NSLS, e.g., x-ray anomalous dispersion, extended x-ray absorption fine structure (EXAFS), near-edge x-ray absorption fine structure (NEXAFS), photoemission spectroscopies (PES), and Fourier-transform infrared spectroscopy (FTIR). The BNL Chemistry Department staff has extensive supporting expertise in the areas of reaction kinetics and mechanisms, transition-metal chemistry, surface-science, and spectroscopy.

BNL Center for *In Situ* Catalysis and Advanced Materials Studies (CISCAMS)
RESOURCE PROJECTIONS
($ In Millions in Budget Authority)
(Fiscal Years)

	1997	1998	1999	2000	2001
OPERATING	0.3	0.4	0.4	0.4	0.4
CAPITAL	1.2	0.9	0.3	0.1	0.1
TOTAL	1.5	1.3	0.7	0.5	0.5

Gas phase studies address molecular photofragmentation dynamics and characterization of the structure, spectroscopy and intramolecular dynamics of chemical intermediates important in combustion chemistry. Coherent VUV and ultra-fast laser sources are used to induce photo-processes such as ionization, dissociation, intramolecular motion and desorption, the dynamics of which are probed by a variety of state- and energy-resolved ionization-based techniques and nonlinear pump-probe spectroscopy. Related work explores the energetics, dynamics and chemical reactions resulting from molecular collisions in the gas phase. Of key interest are the microscopic factors affecting the structure, dynamics and reactivity of short-lived intermediates in gas phase reactions important in combustion chemistry. Molecular species are studied using both experimental and theoretical tools including high resolution spectroscopic probes, quantal wavepacket propagation, and time-independent quantal calculations. In a new initiative, radical-radical kinetics will be studied via laser photolysis and discharge-flow production of molecular radical reactants and time-resolved mass spectrometric product sampling techniques. Very high laser intensities are exploited to investigate the response of molecules to intense fields well beyond the perturbative regime which introduces new selectivity and "field induced" fragmentation pathways. The effects of well characterized fields on simple, isolated systems are also under investigation with the ultimate goal of optimal control of physical and chemical processes. State-resolved, VUV detection methods are also being implemented in new studies of photoinduced desorption of molecules from surfaces. These studies focus on elucidating the mechanism of photoinduced desorption via measurements of the quantum state and energy distributions of the desorbed molecules and/or molecular fragments. Other studies utilize *in-situ*, time-resolved, sum frequency generation spectroscopy for probing the structure and dynamics of surfaces.

RESEARCH INITIATIVE

Radical-Radical Reaction Kinetics Related to Combustion

The most important unanswered questions in basic research related to combustion are product identification, branching ratios, and rates of chemical reactions between two free radicals. First-principles calculations of these quantities are far beyond current capability, and models must therefore rely on careful experimental measurements. Attempts to develop improved models of combustion processes and emissions must ultimately rely on such information. Progress in this field has been slow, due to the experimental difficulty of making quantitative measurements on radical-radical systems, and there are very few centers in the world with strong programs dedicated to radical-radical reactions. We plan to design and construct a new experimental apparatus based upon laser photolysis and discharge-flow production of molecular radical reactants and time-resolved mass spectroscopic product sampling techniques. We believe that careful experimental design along

these lines will enable a major increase in the knowledge base crucial for reliable modeling and detailed understanding of combustion processes.

Radical-Radical Reaction Kinetics Related to Combustion
RESOURCE PROJECTIONS
($ In Millions in Budget Authority)
(Fiscal Years)

	1997	1998	1999	2000	2001
OPERATING	0.3	0.3	0.3	0.5	0.5
CAPITAL	0.2	0.2	0.2	0.1	0.1
TOTAL	0.5	0.5	0.5	0.6	0.6

In solution based work, issues fundamental to the efficient capture and storage of light energy are addressed: excited-state formation, chemistry, and photophysics; energy transduction by electron- transfer reactions; and energy storage through chemical transformations. Theoretical and experimental efforts elucidate the factors controlling excited-state lifetimes and electron-transfer rates; the roles of electronic configuration, donor/acceptor separation, bridging groups, nuclear-configuration and free-energy changes, as well as the role of solvent dynamics are being investigated through studies of transition-metal complexes and other donor/acceptor systems. Pulse radiolysis and flash photolysis techniques are being used to generate and characterize transient species important in solar energy conversion, including the preparation and properties of transition-metal complexes in unusual oxida-tion states and their ability to bind and activate small molecules, and to determine bimolecular and intramolecular electron-transfer rates. The properties and reactions of electrons and other ions in dielectric fluids are being studied utilizing both X-ray and high energy electron sources. The long-term storage of solar energy as fuels or valuable chemicals requires efficient coupling of light absorp-tion and chemical transformation processes. Mechanistic studies of systems which couple photo-induced electron-transfer processes to the bond-forming reactions required in the photogeneration of hydrogen and the photoreduction of carbon dioxide to useful chemicals are a major focus. In a new direction, the greater penetrating power of the electron beam of the new pulse radiolysis facility will provide uniform dose distribution inside high-pressure cells, enabling quantitative equilibrium measurements. The new pulse radiolysis facility will also be used to generate and characterize short-lived charge- transfer excited states of transition-metal complexes.

The unique capabilities of the HFBR are being utilized in a wide range of neutron diffraction studies. For example, accurate structures determined for transition-metal hydrides are relevant to homogeneous and heterogeneous catalysis applications and complement current research on metal hydride reactivity patterns. At the NSLS, the high brightness and extreme collimation of x-rays are providing important advantages for crystallographic studies, e.g., real time, in situ powder diffraction investigations of zeolite hydrothermal synthesis, studies of high-T_c superconducting metal oxides and pioneering studies of biomineralization phenomena. The NSLS x-ray ring also is proving to be a unique resource for investigating the nature of complex reaction intermediates on single-crystal surfaces. Surface science studies aimed at elucidating fundamental aspects of heterogeneous catalysis employ a wide variety of experimental techniques including angle-resolved ultraviolet photoelectron spectroscopy, thermal desorption spectroscopy, and infrared reflection-absorption spectroscopy. A synchrotron end-station, equipped with a broad complement of diagnostic tools needed for the identification of surface intermediates and adsorbed species, has been constructed for surface science studies in the UV and soft x-ray regions.

Porphyrin chemistry studies address the conversion of light into chemical energy by chlorophylls in photo-synthesis and catalytic reactions such as nitrogen assimilation and carbon dioxide conversion mediated by the broad class of porphyrins. The project encompasses structural, experimental and theoretical methods. Major

efforts in progress include x-ray diffraction and x-ray absorption studies at the NSLS that yield structural data on reaction transients; theoretical calculations that model electron transfer in catalytic reactions, and the effects of conformational variations on photochemical and photo physical properties.

Electrochemical and photoelectrochemical investigations of heterogeneous electron transfer processes are continuing. Our experiments focus on determining the factors which control heterogeneous electron transfer: e.g., distance between the electrode and the redox moieties, the nature of the intervening medium, the nature of the redox moiety, the solvent, the electrolyte. A laser induced temperature jump method has been developed and is being used to measure very fast (nanosecond time domain) heterogeneous electron transfer processes. Computer modeling of a variety of electrochemical and photoelectrochemical systems continues to be a significant facet of this program.

Both the fundamental and practical aspects of the behavior of metal hydride electrodes are under study with a view towards improving the energy density and performance of metal hydride - nickel batteries. A critical problem is the corrosion of the hydride electrode in the battery environment. It has been determined that the presence of Ce in the AB_5 metal hydride electrodes decreases corrosion, thereby significantly increasing electrode cycle life. It is likely that the protective mechanism involves the formation of a layer of CeO_2 on the electrode surface. It was also shown that the amount of expansion and contraction, associated with hydride formation and decomposition, of a metal hydride electrode is directly correlated with electrode corrosion.

Combustion kinetics studies on elementary reactions employ a multi-technique approach to perform direct rate constant measurements over an exceptionally wide temperature range: 300 to 2500K. A discharge flow-photoionization mass spectrometer utilizes tunable, high intensity, synchrotron radiation at beamline U11/NSLS to achieve unique selectivity and sensitivity capabilities in reaction pathways experiments (to determine branching fractions) and in thermochemical studies of molecular and radical species (to determine heats of formation).

Novel laser-based spectroscopic methods for the analysis of microparticles continue to be develop-ed. This technique builds a fundamental understanding of the physics and chemistry of these parti-culates which govern such diverse processes as materials processing in manufacturing, global climate change, combustion, and other energy-related phenomena.

Advanced analytical techniques are being developed that rely on novel uses of ion and photon beams. Microanalysis with fentograms detection limits and 100 m^2 spatial resolution is underway using x-ray beams at the NSLS. The Applied Physics program is involved in trace element analysis for biomedicine, geochemistry, and cosmochemistry.

Studies of structure and function relationships in electrochemical processes are aimed to establish the relationship between the electrode surface structure and its electrochemical activity, the ultimate goal being the prediction of the surface catalytic properties. *In situ* determination of the surface structure, during the course of an electrochemical reaction, is being carried out with atomic resolution by surface x-ray scattering at the NSLS and by scanning tunneling microscopy. FTIR spectroscopy will be used for *in situ* identification of reaction intermediates and products. Structure of the active sites for electrocatalytic reactions on clean and metal adlayer modified single crystal surfaces, recon-struction of stepped single crystal surfaces and novel metal-metal oxide electrocatalysts for methanol oxidation are the major topics of this research. The results may have applicative potential for electro-chemical energy conversion sensors and electroorganic synthesis.

A new study which seeks as its objective to determine the mechanisms of microbial dissolution and stabilization of radionuclides and toxic metals present in DOE waste and to determine the changes therein brought about by microbial activity at the molecular level is underway.

RESEARCH INITIATIVE

Center for Radiation Chemistry Research

A specially designed 10 MeV electron accelerator is near completion and will be the core facility of the new Center for Radiation Chemistry Research (CRCR). The accelerator employs a picosecond laser to generate electron pulses as short as 5 picoseconds for pulse radiolysis. The combination of short pulse durations, high dose rates, and high penetrating power will greatly extend the BNL capabilities in this area and both academic and industrial scientists will be encouraged to use this facility. Important applications include picosecond pulse radiolysis, high-pressure radiation chemistry, and combined radiolysis-laser photolysis experiments; the new features will permit the study of very rapid chemical reactions that are important in catalysis and in energy conversion and storage.

Engineering and Geosciences (KC-04)

The role of the chemistry of polysulfides in rich marine sediments -- the incorporation of sulfur into organic matter and the effect of such incorporation in the preservation of sedimentary organic matter is being studied. A collaboration with Woods Hole Oceanographic Institution on the chemical speciation of sulfur in marine sediments and sediment extracts using XANES spectroscopy at the NSLS is underway.

Investigations of the microgeometry of rock pores are being carried out using synchrotron computed microtomography (CMT). These studies will allow an understanding of the movement of fluids, such as oil and oil-displacing brine in geological formations.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
KC-04 ENGINEERING AND GEOSCIENCES								
Operating	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Capital Equipment	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Cost	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Direct Personnel	1	2	3	3	3	3	3	3

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

Energy Biosciences (KC-06)

Fundamental and applied research is directed toward a fuller understanding of genetic, physiological and biochemical mechanisms of higher plants. Recombinant DNA technology is used to develop genetic and physical maps of economically important plants such as maize. Such maps greatly facili-tate the identification of genetic factors that control or influence desirable traits, and increase the efficiency of plant breeding. Related studies of transposable elements increase basic understanding of genetic mechanisms and could also have practical application for plant breeding, particularly for gene isolation.

The structure and functioning of the photosynthetic membranes of cyanobacteria and higher plants are studied, including mechanisms governing the distribution of excitation energy and the pattern of electron transport. Protein kinases and phosphatases that regulate photosynthetic processes are being isolated and characterized, and the genes that specify them are being cloned and sequenced.

The biochemistry and molecular genetics of lipid desaturation in plants is being analyzed. Desaturation is important for lipid synthesis, membrane biogenesis, and production of plant oils. Increased understanding of the process might enable plants to be modified so as to produce more oil or more valuable types of oil. The mechanism of protein turnover, an important part of the plant's response to changing environmental conditions, is also being studied.

We would like to initiate additional programs of research on the molecular genetics and structural biology of higher plants and thermophilic bacteria. We are particularly interested in programs that would reinforce and amplify our current efforts and take advantage of the facilities available at BNL.

Systematic studies of the biochemical interactions between thermophilic and thermoadapted microorganisms and heavy crude oils have shown that such reactions occur at several sites containing heteroatoms, e.g., sulfur, nitrogen, and trace metals. Chemically, these heteroatom sites are asso-ciated with compounds concentrated in the heavy crude oils and high molecular weight oil fractions. Although additional studies are essential in order to understand the science behind these reactions, early results from these basic studies have already found potential applications in oil and petroleum processing.

PROGRAM SUMMARY ($ in Millions in Budget Authority) (Personnel in FTE) (Fiscal Years)								
	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
KC-06 ENERGY BIOSCIENCES								
Operating	1.0	1.1	1.3	1.3	1.3	1.3	1.3	1.3
Capital Equipment	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1
Total Cost 1.1	1.2	1.5	1.5	1.4	1.4	1.4	1.4	
Direct Personnel	6	7	8	8	8	8	8	8

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
**Constant FY1998 dollars

Applied Mathematical Sciences (KC-07)

The major emphasis of the work under this program at BNL is directed toward the national High Performance Computing and Communications Initiative. It involves work in the development of improved mathematical methods for solving partial differential equations on massively parallel computers, the development of software tools for concurrent asynchronous execution of data coupled component programs, and the use of visualization techniques for the study of complex nonlinear dynamical systems. As part of a cooperative effort with Oak Ridge National Laboratory, Ames National Laboratory, and several universities, including a close collaboration with Stony Brook, the particular grand challenges to be addressed are first principles calculations of material properties and contaminant transport in groundwater.

Most scientific disciplines are becoming increasingly computationally intensive, and many of the resulting challenges overlap many disciplines. We intend to pursue vigorously the establishment of cooperative computational activities to avoid duplication and provide cross-fertilization of techniques.

PROGRAM SUMMARY ($ in Millions in Budget Authority) (Personnel in FTE) (Fiscal Years)								
	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
KC-07 APPLIED MATHEMATICAL SCIENCES								
Operating	0.9	0.8	1.0	1.0	1.0	1.0	1.0	1.0
Capital Equipment	--	--	--	--	--	--	--	--
Total Cost 0.9	0.8	1.0	1.0	1.0	1.0	1.0	1.0	
Direct Personnel	4	5	3	4	4	4	4	4

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
**Constant FY1998 dollars

BIOLOGICAL AND ENVIRONMENTAL RESEARCH (KP)

These programs at BNL are carried out in the Applied Science, Biology, Chemistry and Medical Departments. Their efforts include medical applications of nuclear technology, basic and applied molecular, structural, cell and radiation biology, epidemiology, and many facets of environmental research such as acid precipitation, oceanography, soil science and CO_2 research. The programs draw their strengths from 1) basic research by first class investigative groups who interact strongly, within and between departments; 2) interaction with other laboratories, med-ical schools and hospitals; and 3) the presence at BNL of unique, specialized instruments and facilities open to scientists from BNL, and collaborators from other laboratories, universities and industries. These facilities include the High Flux Beam Reactor, National Synchrotron Light Source, Scanning Transmission Electron Microscope, Brookhaven Linear Isotope Production, Medical Research Reactor, and Positron Emission Tomography Center.

Analytical Technology (KP-01)

Advancements in atmospheric tracers and related instrumentation is directed at improving the resolution, speed, and automation of the analyses through the use of megabore columns, capillary columns, pressure-balance switching techniques, on-column cold trapping, and improving the precision of the laboratory analysis and calibration system.

Environmental Research and Physical and Technological Research (KP-02)

Brookhaven National Laboratory is unique in the national laboratory system with field research components in oceanographic, atmospheric, and terrestrial sciences. These programs involve multidisciplinary efforts utilizing knowledge in the fields of chemistry, physics, biology, and the application of several kinds of engineering.

Land based studies include topics such as the mechanisms of microbial degradation of organic complexing agents. It has been shown that these materials can mobilize buried radionuclides and toxic metals at contaminated sites. The persistence of chelating agents in the disposal environment is a major concern because of the potential for increasing the transport of radionuclides and toxic metals beyond the site boundary. Information obtained from this study can be used in environmental restora-tion work by enhancing the biodegradation of these agents found in mixed waste at contaminated sites.

In the same vein, mechanisms by which aerobic and anaerobic microbes, in particular, heterotrophs, regulate the mobilization or stabilization (immobilization) of uranium, thorium, and rare earth elements in radioactive mineral deposits, are examined. Knowledge of the basic mechanisms of aerobic microbial dissolution of radionuclides from mineral deposits in the oxidizing front and immo-bilization by anaerobic microbes in the reducing front as well as in radioactive wastes will be useful for the long-term performance assessment of nuclear waste repositories.

New work includes a study addressing the hypothesis that there is a decreasing capacity for terrestrial photosynthesis and primary production with global atmospheric changes in CO_2 levels.

The Oceanography Program at Brookhaven National Laboratory examines the natural and anthro-pogenic processes at the continental ocean margins. The main focus of the work is to determine whether continental shelves remove significant amounts of atmospheric carbon dioxide and isolate this carbon dioxide from recirculating to the atmosphere. Efforts include basic research on biogeo-chemical cycles in the ocean, especially in relation to transfer of fluid and particles between continental shelves and slopes. Despite the fact that this is DOE's only ocean going program, its funding has been seriously threatened.

Significant research efforts on the overall role of the oceans in the forcing and feedback of climate is ongoing. These efforts include molecular, ecosystems and global synoptic scales as deduced from laboratory, field and satellite information. Integration of these levels via unique instrumentation developed and built at BNL has made major contributions to the advancement of oceanography worldwide.

In support of these goals, individual areas of research focus on molecular ecology, modelling, satellite measurements, and unique instrumentation development to support a significant experimental presence at sea.

In the area of atmospheric and environmental chemistry, BNL is engaged in several studies related to airborne gaseous and particulate pollutants. We, along with Argonne National Laboratory and Pacific Northwest Laboratory, are conducting a joint program entitled Continental and Oceanic Fate of Energy Related Air Pollutants, whose object is to obtain an understanding of the processes that occur in the atmosphere that control the transport, transformation, and ultimate fate of air pollutants that are emitted in conjunction with energy related activities. Building upon the results of research conducted during the National Acid Precipitation Assessment Program, emphasis is being placed on the fate of sulfur and nitrogen compounds, and the oxidants that can influence their behavior.

In support of the broad program goals, specific topics in environmental chemistry include: 1) the development of methods of the detection and measurement of atmospheric constituents at ambient levels for use in field studies and laboratory experiments; 2) theoretical, laboratory, and field studies directed at understanding the formation and behavior of aerosols; 3) studies engaged in the measurement and understanding of the formation of gaseous and particulate pollutants as they mix with ambient air; 4) modeling studies involving the kinetics of chemical reactions taking place among pollutants and with water vapor in the atmosphere; 5) laboratory and field studies directed at understanding the mechanisms involved in the incorporation of sulfur and nitrogen into cloud water with the consequent formation of acid rain; 6) theoretical and observational studies of radiative transfer and fluxes in the atmosphere; and 7) analysis of data relative to global climate change.

The Tracer Technology Center is developing new laboratory systems for analysis of perfluorocarbon tracers (PFTs) in its labs and is working with industry partners to commercially produce several versions motivated by use of BNL's equipment in the recent European Tracer Experiment (ETEX) and in leak locating projects for the utility industry. An important other application related to the building ventilation industry is in developing a commercial strategy for evaluating the performance of hospital isolation rooms' ventilation controls to minimize the spread of contagious diseases.

Health Effects (KP-03)

Studies on characterization of genetic changes critical for carcinogenesis induced by environmental agents, i.e. radiation and benzene are actively conducted. New methodologies in cytogenetics and molecular biology are being used to identify such changes. The combined approach enables investi-gation of involvement of the cancer-specific chromosomal alterations in activation, amplification, or structural alteration of proto-oncogenes, inactivation of tumor-suppressor genes as well as expression of such genes during carcinogenesis. More importantly, results from this research program will provide valuable information on the comparative aspects of carcinogenesis by radiation and the chemical carcinogen, benzene.

Cytogenetic studies of radiation-induced myeloid leukemia (ML), using a G-banding technique, have suggested that a deletion in regions D-E of mouse chromosome 2 [del2(D-E)] is a genetic marker for radiation-induced ML. Subsequently, a study uniquely designed to determine the precise role of lesions on chromosome 2 in radiation leukemogenesis was conducted. Results have indicated that region 2F and 2H are hypermutable leading to the neoplastic transformation of myeloid cells. Our study is unique in that, while other similar studies focus on clinically diagnosable leukemia, our concentration is on the latent period between the exposure and the appearance

of the disease. Efforts are being made to identify gene changes resulting from these chromosomal lesions and to determine which of these changes is the initiating event for leukemogenesis.

General Life Sciences (KP-04)

Basic Research

Our basic research programs are directed primarily toward understanding genetic and biochemical processes and structure-function relationships. We study genome organization, DNA damage and repair, replication, genetic recombination, mutagenesis and carcinogenesis, control of gene expression, mechanisms of enzyme action, and structures and functions of proteins and complexes such as chromatin, ribosomes, viruses and membranes.

This strong core of basic research gives us the capability and flexibility to respond to DOE initiatives such as those in structural biology, genome research and biotechnology. A strength of our user facilities is that they developed from and interact with these programs of basic research. Having programs here that depend on these facilities for scientific results ensures that the facilities will be stretched to perform as well as possible and that they will function as they should when used by researchers from the wider community. Research at BNL that depends on these facilities includes: determining the crystal structures of ribosomal proteins, histones, and regulatory proteins; using Laue diffraction to analyze structural changes during protease action; mapping the locations of specific proteins in chromatin; analyzing viral assembly pathways and intermediates; studying the action of chaperonins in protein folding; characterizing secondary structures of proteins and nucleic acids by circular dichroism and time-resolved fluorescence spectroscopy; analyzing the binding of transcription and replication factors to DNA; and elucidating interactions of drugs with viruses and membrane proteins.

Structural Biology Facilities

The Laboratory has a unique set of facilities for structural biology, including stations for x-ray scattering and vacuum ultraviolet spectroscopy at the NSLS, stations for neutron scattering at the HFBR, and the scanning transmission electron microscope (STEM) for high resolution measurement of molecular shapes and masses. These facilities were developed here and are continually maintained, upgraded and made accessible for research. They are used by an active core of workers at the Laboratory and by a wider community of researchers in universities and industry.

These facilities represent a powerful combination of tools for examining structures of macromolecules. The types of information obtainable include the 3D location of atoms in individual molecules or structures, the arrangements of molecules in higher order structures, and the overall shapes and interactions of complexes of molecules. Such information is basic for understanding how biological molecules and structures function, which in turn provides critical insights and support for molecular genetics, biotechnology, genome research and medicine.

We plan to develop additional user facilities to benefit the community, including more protein crystallography stations at the NSLS, stations for neutron Laue crystallography and fiber diffraction at the HFBR, a station to study biological samples with an ultraviolet free-electron laser (FEL), a cryo electron microscope for imaging frozen-hydrated specimens, and an improved atomic force microscope (AFM) for imaging biological macromolecules.

To leverage DOE resources, we are working with regional crystallography groups to develop and operate new stations for protein crystallography at the NSLS. To become a member of a Participating Research Team, a regional group provides a fraction of the resources needed for a crystallography station in return for guaranteed access to synchrotron radiation. An experienced group of BNL scientists and technicians works with the outside group to help them develop and manage a state-of-the-art station. The new facilities benefit regional

crystallography groups directly and also provide increased capacity for other users, who may apply for time through the general user program administered by the NSLS.

Protein Data Bank

The Protein Data Bank (PDB) is the depository of three-dimensional structural information for all types of biological macromolecules. In recent years, an explosion of activity in structure determination has rapidly increased the size of the PDB and made it an increasingly important resource for structural biology, molecular genetics and genome studies. Researchers are placing demands on the PDB for new kinds of information and new ways of dealing with it. Interactions between the PDB and the researchers who rely on it are critical for maintaining a resource that supplies the needs of the biotechnology revolution.

The Protein Data Bank has recently moved to newly constructed space in the Biology Department. Close interaction between the PDB and researchers in the Biology Department should benefit both groups and help the PDB to appreciate and respond to the needs of the user community. Closer relationships between the PDB and outside research groups are also being established.

Genome Sequencing Center

New technology for large-scale DNA sequencing is being developed, using primer walking from a hexamer library. This technology could provide the basis for highly efficient, fully automated sequencing machines that could allow the human genome to be sequenced within the time frame and budget of the Human Genome Project.

Substantial progress is being made in validating our sequencing procedures and developing the necessary components for fully automated sequencing. Protocols for primer walking with hexamer strings have been implemented for automated fluorescent sequencing. Vectors have been developed that allow stable cloning and convenient preparation of 35,000-bp segments of genomic DNA. We have successfully tested a prototype instrument for capillary electrophoresis through a replaceable matrix and are constructing a module suitable for production sequencing. The data management requirements for large-scale sequencing are formidable, and we have begun to develop a system to allow the entire sequencing process to proceed with little need for human intervention.

To drive the development of this technology, we are sequencing the 1-Mbp genome of the bacterium that causes Lyme disease. Developing software and databases for managing the sequencing process will continue to be a major effort for the next few years. As procedures become standardized, we plan to automate them, aiming for an integrated system that minimizes the need for human involve-ment. We expect our sequencing capacity to expand steadily, reaching a rate of hundreds of Mbp per year within a few years. As our sequencing capacity increases, the majority of our effort will shift to sequencing the human genome. However, we plan to continue a substantial effort in sequencing microbial genomes, which will provide a wealth of information of importance for medicine, for environmental remediation, and for industrial processes based on enzymes. We hope to become a major Genome Sequencing Center.

Informatics and Computation Biology

Even at current rates of DNA sequencing, we face a considerable challenge in interpreting, annotating and learning from genomic sequences. As the rate of sequencing increases, this will become a critical problem. We consider it crucially important to establish a substantial Informatics and Computational Biology group to focus on what the sequence means and to develop new ways of learning from it, such as comparing complete genomes, families of genes, motifs and characteristic structures, understanding metabolic pathways, predicting function from sequence, and calculating protein folding, structures and interactions. This group will interface naturally with the

Protein Data Bank and our programs in molecular genetics and structural biology and should impact wide areas of molecular biology and biotechnology.

Carbon Dioxide Research (KP-05)

Studies on the mitigation of the global CO_2 greenhouse effect are being conducted. The studies include assessment of physical, chemical and biological methods of reduction of atmospheric CO_2, and the effect of improved energy technologies for utilization of carbonaceous fuels in various regions of the world.

User facilities for experiments on plant and ecosystem responses to CO_2 enrichment are designed, built and operated under the Free-Air Carbon Dioxide Enrichment (FACE) program at BNL and at several locations in the United States and abroad. These facilities, developed in collaboration with the university community, are platforms for the integrated research efforts of dozens of principal scientists, graduate and post doctoral students examining plant system organization. BNL has dual roles in this program with primary responsibility for the development, installation and verification of the performance of FACE instrumentation. We are also a leading contributor to research at FACE facilities in plant physiology and molecular biology. The primary purpose of the research is to obtain a set of data on the effects of CO_2 enrichment on plants in order to validate the performance of physio-logical process models. These models will contribute to evaluating effects of global change on plant systems and the role played by terrestrial vegetation is regulating atmospheric CO_2. A prototype FACE system for use in tall forest canopies is under development. BNL FACE systems are currently operating in Arizona, North Carolina and Switzerland. BNL will continue to build and operate FACE systems in the U.S. and abroad as part of an expanding International Geosphere Biosphere Program core project "Global Change in Terrestrial Ecosystems." A project entitled, "Forest-Atmosphere Carbon Transfer and Storage", and a companion project at Duke University will expand the FACE facility at the Duke Forest creating a multi-disciplinary, multi-institutional integrated research experi-ment on the processes regulating forest carbon balance at scales ranging from molecular to the forest ecosystem.

Global Change (KP-05)

Rising carbon dioxide levels over the last 150 years has led to concern and controversy about the possibility of a global temperature rise which could cause severe changes in precipitation patterns and sea level, and shifts in agriculturally productive regions. The temperature rise predictions are based upon forecasts from global change models that attempt to simulate the world's climate. A particularly difficult problem in these models arises from the coupling of atmospheric temperature with the ocean's enormous capacity to absorb heat.

The mission of BNL's global change program, together with similar programs in the U.S. and internationally, is to conduct research that will establish confidence in understanding global change, with the ultimate goal of incorporating that knowledge into a computer model that describes the earth's ecosystem and how it will respond to change. BNL scientists will take advantage of their expertise in measuring trace atmospheric constituents and describing their transport, transformation and removal processes; understanding the physical, chemical and biological processes in the ocean; studying the effects of increased carbon dioxide on vegetation; and the role of terrestrial vegetation in regulating the rate of increase of atmospheric CO_2. BNL researchers in conducting and managing field projects in the U.S. and abroad will play a major role in forthcoming research related to global change. The program involves field measurements, field and laboratory experiments, analysis and interpretation of historical data sets and information derived from satellite measurements, and computer modeling of the processes involved in global change. Much of the work will be done in collaboration with other institutions and with national and international programs.

The intrinsic variability of climate dynamics is being investigated using low-order models and empirical data, with the goal of improving confidence in detecting anthropogenic greenhouse warming. Geometric phase-space

structures are sought using statistical methods, linear spectral theory, and nonlinear dynamics techniques such as phase space reconstruction and recurrence plots. Linear and nonlinear structures would have very different implications for the forecastability of intrinsic climate fluctuations. Techniques applicable to empirical data series will be used to analyze model simulations. From the forecastability of the model-generated data, guidance will be drawn as to expected structure and forecastability of empirical data. Proxy data suitable for similar analysis will be identified. A preliminary estimate of the possibility of improved confidence in detecting a greenhouse signal will be weighed.

Research on the radiative properties of non-uniform clouds focusses on the influence of the varia-tion in cloud properties over various spatial scales on specification of the domain averaged (e.g., a general circulation model (GCM) grid box) radiative budget. The approach is to carry out both theoretical and observational studies of radiative transfer. These studies will 1) subject a range of current parameterizations of cloud microscopic and macroscopic properties used in calculating cloud radiative properties to rigorous test; 2) assess the effects of cloud inhomogeneities on domain averaged radiative properties as calculated from these parameterizations; 3) perform radiative transfer calcula-tions for clouds with non-homogeneous microphysical and geometric properties; 4) develop new methods for modeling radiative transfer through the atmosphere that contains broken cloudiness; and 5) evaluate methods of retrieval of cloud droplet size distributions and liquid water path from spectral radiance measurements. The anticipated benefit of this research will be development of new and better predictions of cloud radiative transfer which can be directly incorporated into GCMs.

Studies are being conducted on cloud albedo perturbations on climate. The objectives are to calculate shortwave albedo enhancement and radiative forcing by sulfate aerosols due to direct light scattering and to increased cloud reflectivity for specific locations and times corresponding to satellite measurements; to compare the calculations with the measurements; to determine the sulfate-induced shortwave radiative forcing of climate as a function of location and time over the industrial period; to examine for hemispheric or regional temperature anomaly trends due to geographically nonuniform forcing; and to relate temperature trend to a change in radiative forcing, thereby providing an empiri-cal measure of the sensitivity of climate change to a change in radiative forcing.

A project to measure inorganic carbon is directed at making highly accurate measurements on discrete samples, at sea, of TCO_2, pCO_2, and pH during World Ocean Circulation Experiment (WOCE) cruises. The goal is to contribute toward the understanding of CO_2 fluxes within the ocean, and between the ocean and atmosphere. Coulometric titration is employed for TCO_2, with a coupled flow-through Ph cell. For pCO_2, an innovative, rapid headspace gas chromatography method is employed. These three parameters are measured on most WOCE samples. Without compromising the inorganic carbon program, Brookhaven National Laboratory (BNL) researchers also measure carbon tetrachloride (and Freons) on selected WOCE legs and institute collection of basic biomass data at all CO_2 stations (e.g., chlorophyll a, particulate organic carbon (POC), particulate organic nitrogen (PON), euphotic zone depth). The biomass measurements allow carbon cycling to be related to remotely-sensed variables (e.g., chlorophyll). Data sets of sufficient density are collected to allow calculation of carbon fluxes and storage using water mass transports and ocean circulation models. Of particular interest is identification of a relationship between excess CO_2 penetration and biologically inert, anthropogenic halocarbon distributions.

Instrumentation is being developed for the ARM UAV (Unmanned Aerospace Vehicle) project. This vehicle will fill a pressing need within the cloud - atmosphere - radiation community to make lengthy meteorological and radiative measurements at altitudes up to the top of the troposphere. The responsibility at BNL is for the non-radiometric instruments.

Medical Applications (KP-06)

This program emphasizes the development and testing of new radiotherapeutic procedures and new radiopharmaceuticals including monoclonal antibody immunoconjugates and labeled probes designed to target disease-associated molecular receptor sites for use in diagnosis and therapy. Collaboration within the Laboratory and with outside institutions is expanding as efforts are made to increase the availability of the Department's instrumentation, new and unique radionuclides, radiopharmaceuticals, and technical expertise to the medical, radiology and oncology communities.

Specific project areas include: Investigating new single photon emission computed tomography (SPECT) imaging procedures and new radiotracers for SPECT imaging, investigating methods to improve the quantitative accuracy and resolution characteristics of SPECT imaging and studies of comparative kinetics, dosimetry and utility of selected single photon emitting radionuclides in certain diseases and metabolic processes. Major effort is directed at; the development of new radiotracers and ligands for brain research and for tumor diagnosis and monitoring the progress of the disease and therapy; utilization of the unique whole-body counting facilities to study distribution and metabolism of compounds following administration of extremely low doses of radioactivity.

The use of Positron Emission Tomography (PET) for the investigation of basic processes underlying disease and the evaluation of possible clinical applications of PET is described in more detail in the section of PET and Cyclotron research.

The Biomedical Isotope Resource Center (BIRC) project's goal is to improve the BLIP and Target Processing Laboratory facilities for isotope research and production and operate the facilities on a year-round basis. Construction is scheduled to be completed by September, 1996. Since DOE has decided not to proceed with the construction of the National Biomedical Tracer Facility (NBTF), at this time, the upgrade will allow BLIP to better respond to the mounting national need for radioisotopes.

New radionuclides, in particular gamma/beta and positron emitters for labeling monoclonal antibodies and peptides for radioimmunodiagnosis/therapy of cancer, are being developed and new more preorganized chelating agents that improve in-vivo radioimmunoconjugate distribution are being synthesized. New approaches to targeting radioisotopes to malignant cells, including the use of receptor-specific agents, are studied. A number of collaborative projects are in progress for develop-ing clinically useful radioimmunoconjugates. Collaborative efforts with the University of Nantes, the Wistar Institute, NYU Medical Center, and the University of Nebraska Medical Center include the development of better methods for the attachment of gamma and positron emitters to antibodies for tumor imaging in patients, and the investigation of antibodies labeled with gamma/beta/auger isotopes e.g., scandium-47, copper-67, and platinum-195m for radioimmunotherapy of breast and colon cancer. In collaboration with U.C. Davis, a therapy trial using Lym-1 antibody labeled with BNL-developed copper-67 is in progress in lymphoma patients and has given very encouraging results in the first few patients. In a joint effort with SUNY, Stony Brook, VA Medical Center, Tucson, Arizona, North Shore University Hospital and the University of Cincinnati, a Phase II human therapy trial under BNL sponsorship in 47 patients has shown great promise for the use of tin-117m-DTPA for treatment of metastatic bone pain in breast and prostate cancer patients. Approximately 75% of the evaluable patients experienced significant to excellent relief of pain without any hemopoietic toxicity. This technology has been licensed to Diatide, Inc., for further development and commercialization with support from a new CRADA. Under another CRADA involving BNL, Yale, and American Biogenetic Sciences, agents specific for the PET imaging and therapy of thrombosis and other vessel wall disease have been developed and tested. Mallinckrodt, Inc., under an exclusive AUI license, continues distributing the FDA-approved commercial version of the BNL technetium-99m-RBC kit. Under a personnel exchange program, new sensitive imaging devices for PET and SPECT that use plastic scintillating fiber technology are being developed and tested in collaboration with the Southwestern Medical Center in Dallas, TX.

A project that is expected to continue to grow during the plan period is boron neutron capture therapy (BNCT). BNCT is a two-component radiotherapy technique that requires selective delivery of ^{10}B-containing

drug to the tumor in conjunction with irradiation of the tumor region with slow (thermal or epithermal) neutrons. The boron-10 nucleus captures thermal neutrons efficiently and immediately disintegrates to release heavy charged particles (alpha particle and ^{7}Li ion) that travel less than 10μm in tissue. Given sufficient selectivity of the boron-containing drug for the tumor, BNCT can result in tumor-to-normal-tissue dose ratios unprecedented in radiation therapy. The Brookhaven Medical Research Reactor (BMRR) was designed and built primarily for biological and medical research, in particular it was designed for flexibility in effecting BNCT, and it is one of the best facilities in the world for this purpose. Two irradiation facilities are available at the BMRR, the "Thermal Neutron Port" and the "Epithermal Neutron Port". The thermal neutron beam is used for cell culture irradiations and for small animal experiments. The epithermal beam generates thermal neutrons at depth in tissues (using tissue as the moderator) for interaction with ^{10}B targeted to deep-seated tumors. An FDA-approved clinical trial is underway for BNCT of malignant glioma using the epithermal neutron beam at the BMRR and the boronated amino acid, p-boronophenylalanine (BPA). Standard therapy for malignant glioma consists of surgical removal of the tumor followed by photon radiation therapy. In the BNL clinical trial, the photon radiotherapy is replaced by BNCT, given 3-5 weeks after the debulking surgery. The clinical trial is based on extensive preclinical studies in animals as well as on distribution studies of the drug BPA in glioblastoma patients undergoing surgical removal of their tumors. The distribution analysis indicates that, in human glioma free from microscopic necrosis, the boron concentration at the time of surgery (or BNCT) is about 3.5 times higher than the boron concentration present in the blood. The main objectives of the BNCT clinical trial are to evaluate the safety and effectiveness of a series of stepwise increases in BNCT doses to the tumor and to the tumor and to the normal brain. BNCT basic research will continue in order to pro-vide guidance as the clinical trial progresses. Concomitantly, new boron compounds are being developed and evaluated in collaboration with others in an effort to increase selectivity, intracellular accumulation, and to target other tumor types.

Auger Electron Therapy (AET) of cancer is a binary system requiring the simultaneous presence of two agents, a target atom localized in or very near the tumor cell's DNA and a particular radiation source that interacts with the target atom. The interaction yields secondary radiations of cascading Auger electrons, which have very low energy and extremely short ranges (NM), thus depositing large amounts of energy at the point of production, that is, directly in the DNA of the tumor cell. With this approach, surrounding normal tissue is spared the lethal effects of the radiation. AET is being eval-uated with either gadolinium (Gd) or indium (In) as the target atoms. Thermal neutrons and monochromatic photons are the respective radiation sources used for stimulating Auger electron emission. The Gd and In atoms are physiologically delivered to cells by a tumor-seeking porphyrin molecule. Results from preliminary *in vitro* studies with both Gd and In, using cell survival assays that were carried out either at the BMRR or at beam line X27B at the NSLS, show that AET doubles the effectiveness of the dose delivered by the primary radiation. X-ray images of single cells have been obtained using the X-ray microscope at beam line X1A. These pictures confirm that the porphyrin does carry the In target atoms into the cell and localizes them in the cell nucleus.

AET with In and monochromatic photons is being evaluated for its clinical potential in the treat-ment of prostate cancer, and possibly, brain, breast and head and neck tumors as well. For those patients receiving implants of iodine-125 brachytherapy seeds as a treatment for prostate cancer, the addition of the In-labeled compound is expected to double the effectiveness of the radiation dose delivered to the tumor. Since the energy of the iodine-125 seeds is well-suited for inducing photoelectric absorption in the K shell of the In atom, the therapeutic advantage will be a result of Auger electron emission.

The unique properties of the high flux and high energy x-ray beams from the National Synchrotron Light Source (NSLS) are used in research programs in medical imaging and radiation therapy. The ongoing projects include digital subtraction Intravenous Coronary Angiography (ICA), Multiple Energy Computed Tomography (MECT) of the human head and neck, Microplanar Beam (Micro-beam) Radiation Therapy (MRT), and Photon Activation Radiation Therapy (PAT). Clinical and physics expertise in the Medical Department and the NSLS are directed toward carrying out these seminal studies. The ICA, MECT, and MRT research are carried out on the X17B superconducting wiggler beam line, which includes the X17B1 hutch, and the X17B2 room - The Synchrotron Medical Research Facility (SMERF). PAT has been carried out at the X12, X27, and X17 beamlines.

The digital subtraction coronary angiography project is now obtaining images of high quality, unprecedented for this method. The image contrast is enhanced by digital subtraction of two images taken at the K-absorption edge of iodine following intravenous injection of contrast agent. The intravenous injection technique is far safer for the patients than is the conventional high pressure retrograde arterial injection. The system capabilities and reliability have been significantly upgraded in prepara-tion for long term research projects. Human studies will apply the technique to coronary artery atherosclerosis research. This project is a collaborative effort between the NSLS, the Medical Department, the Stony Brook University Health Sciences Center, and Stanford University.

MECT is a monochromatic computed tomography system being developed for imaging the human head and neck. It employs a horizontal fan beam and a subject's chair rotating about a vertical axis. MECT's narrow energy bandwidth (0.2%, compared to 40% in conventional CT) eliminates beam-hardening artifacts. Also, for the same absorbed dose to the patient it has a) less image noise; b) larger image contrast resolution; c) larger image signal with contrast agents (beam energy tuned immediately above the K-edge of the contrast element, such as iodine); d) efficient implementation of the dual photon absorptiometry (DPA) method that gives separate images of the low-Z and the intermediate-Z- element tissue; e) smaller scatter because of the nearly parallel fan-beam geometry; and f) larger quantitative accuracy. At its present preclinical stage, MECT has 2-fold larger iodine signal. Clinical research will include DPA imaging of atherosclerotic plaques in the carotid artery to separate the tissues (i.e., lipid/cholesterol, collagenous, and calcified) from each other.

MRT delivers x-rays to target as microplanar beams, typically 25 to 50 μm wide and several mm high, with 75 to 200 μm center-to-center spacing. MRT at X17B has shown a substantial tissue-sparing effect, up to 1250 Gy. It is postulated that this effect reflects the survival of endothelial cells and, perhaps, other cells between individual slices, which later divide and replace the lethally irradiated ones. Radiotherapy (i.e. MRT) can be implemented by appropriate crossfiring of the target with microbeam bundles, thus eliminating microbeam-mediated tissue-sparing in that volume, while keeping it effective outside that volume. MRT of relatively large 9L gliosarcoma tumors in the rat brain at X17B showed that irradiations are invariably palliative, sometimes curative.

A collaborative program has been started between the NSLS, the Department of Radiology at the University of North Carolina, the Physics Department of North Carolina State University, and the Illinois Institute of Technology to study the possible improvement in mammography image contrast and spatial resolution. The method involves utilizing monochromatic synchrotron x-rays and digital imaging techniques. The program will determine the optimal photon energies and the most efficient detector system for breast tissue imaging. Advanced image processing algorithms will be developed. The X27 beamline is being used in the prototype experiments. Thus far, the contrast of phantoms using monochromatic radiation has been shown to be superior to that of conventional systems.

Biophysical Instrumentation Research. The objective is the development of new instrumentation methods and techniques for structural biology (HFBR, NSLS, and STEM). One area of emphasis will be on research and

development of a variety of position-sensitive detectors which are essential for neutron and x-ray scattering studies of biological structures. The detectors developed for use at the HFBR have the highest accuracy, position resolution and counting rate capability known so far. However, the requirements, especially high counting rates, on the detectors and the large number of different applications at the NSLS are far beyond the present state-of-the-art, so that intensive research into basic detection processes and position sensing methods is required. A second area of emphasis is in the development of a STEM whose object stage is at 4-10K (to minimize sample degradation) and of the use of an energy loss spectrometer as a detector so as to identify, at high resolution, the atomic composition of the object.

Studies in radiological physics will continue to emphasize the development of basic dosimetric data and analytical methods for predicting effects of low doses of ionizing radiation and measurement techniques in mixed radiation fields. Microdosimetry studies will continue with emphasis on developing information and techniques applicable at the nanometer level.

Radiotracer Chemistry and Neuroimaging. The use of Positron Emission Tomography (PET) as a scientific tool in biological and medical research has undergone remarkable growth due in major part to advances in radiotracer chemistry which make it possible to track the regional distribution and kinetics of labeled compounds in the human body. The Brookhaven Radiochemistry and Neuroimaging Program has an international reputation for basic and clinical research with PET which extends from radiotracer development to basic neuroscience and clinical application in the human brain with special emphasis on studies of addiction and other neuropsychiatric disorders and on drug research.

In this "Decade of the Brain", the current program will be updated and expanded to accommodate new developments in the use of PET and other imaging modalities to explore and define normal human biochemistry and the changes that occur in disease and to increase the accessibility of the resources at Brookhaven to the basic and clinical research community and to the pharmaceutical industry. Specific institutional objectives include:

(1) New Positron Emission Tomograph (see Research Initiative). The acquisition of a state-of- the-art, high-resolution positron emission tomograph to supplement the present tomograph which is aging and becoming increasingly unreliable. The present currently scheduled 10 weeks in advance due to an increasing number of in-house and collaborative research projects. No new space is needed since a new PET would be housed in the current building replacing the PETT VI which is no longer used. A state-of-the-art instrument would permit human studies to be performed at lower radiation dose to the patient due to the use of retractable septa. Addi-tionally improved performance in terms of resolution and image quality will facilitate the combination of PET and MRI which we predict will provide information which goes far beyond that which is available from a single imaging modality.

(2) Clinical Neuroscience Center for Drug Abuse (see Research Initiative). The National Institute of Drug Abuse, stimulated by BNL's unique contributions in PET research and drug abuse, is

interested in establishing Clinical Neuroscience Centers to study mechanisms and treatments of drug abuse. A suitable proposal has been submitted to the Office of National Drug Control Policy.

(3) Renovation of the Radiotracer Laboratory. The current radiotracer laboratory will be renovated to update the current crowding and deteriorating space and to specifically include the building of a clean room to meet Good Manufacturing Practice Standards, an FDA requirement by September 1996.

This plan will support an increasingly sophisticated research program dedicated to developing and applying tracer methodology to understanding human and non-human primate physiology. This should lead to a deeper understanding of neurotransmitter behavior and the molecular mechanisms involved in normal function and disease and also permit expansion of our existing studies in addiction, normal aging and the action of substances of abuse and therapeutic drugs. It will also increase the accessibility of Brookhaven's unique facilities and scientific resources for clinical research addressing problems in the diagnosis and treatment of disease and for technology transfer to the pharmaceutical industry in the development and application of new therapeutic drugs. An especially important goal is the full utilization of PET's unique information in the diagnosis and treatment of cancer and diseases of the brain and other organs.

RESEARCH INITIATIVE

BNL Center for Imaging and Neuroscience

The enormous impact of imaging on basic research in the neurosciences and in the diagnosis and treatment of brain disease led to the decision to establish a state-of-the-art Imaging Center at Brookhaven National Laboratory. The Brookhaven Center for Imaging and Neuroscience is dedicated to basic and biomedical research, and to integrating data from positron emission tomography (PET), magnetic resonance imaging (MRI), and single photon emission computed tomography (SPECT), in order to investigate the synergistic uses of multiple imaging modalities in studies of the human and animal brain, as well as other organs. The Imaging Center is being built upon the Brookhaven PET Program, expanding it to include two other imaging modalities, MRI and SPECT. The fully integrated Center is being developed in stages.

A recent stage was the establishment of a High-Field MRI Laboratory. Construction of a new building for this Laboratory is complete. It is located across the street from the PET Laboratory. An MRI instrument that utilizes a superconductor magnet with a field strength of 4 Tesla, the largest used for humans, has been commissioned in FY 1996. This is a cutting-edge instrument for activation studies, for *in vivo* spectroscopy, and for further developing relaxographic imaging, which was originated in this MRI group.

The Brookhaven Center for Imaging and Neuroscience will provide the opportunity to develop new forms of imaging and experimental strategies for investigating *in vivo* molecular mechanisms that go beyond the confines of a single imaging method. As just one example, combining the unique ability of relaxographic MR imaging to map water volumes in tissue with the unique ability of PET to detect minuscule amounts of a rich variety of labeled molecules will allow for the first time the determination of *true* concentrations *in vivo* (without the requirement of physical sampling).

BNL Center for Imaging and Neuroscience
RESOURCE PROJECTION

($ in Millions in B/A - Personnel in FTE)						
		1997	1998	1999	2000	2001
OPERATING		1.5	1.7	1.7	1.7	1.7
CAPITAL	0.4	0.1	0.1	0.1	0.1	
TOTAL		1.9	1.8	1.8	1.8	1.8

RESEARCH INITIATIVE

NIDA Clinical Neuroscience Center for Drug Abuse Research

The National Institute of Drug Abuse has an interest in establishing a number of Clinical Neuroscience Centers for studies of the mechanisms and treatment of drug abuse which was stimulated by Brookhaven's unique contributions in PET research in substance abuse. An interagency proposal has been submitted to the Office of National Drug Control Policy (ONDCP) and National Institute on Drug Abuse (NIDA) requesting funding for a new positron emission tomograph (from ONDCP) and Operating Funds (from NIDA). LDRD funds will be sought for innovative research to design new tracers for receptor ligands of relevance to drug abuse and aging and on ways to relate PET and MRI images.

NIDA Clinical Neuroscience Center for Drug Abuse Research
RESOURCE PROJECTIONS
($ in Millions, constant dollars - B/A)

	1996	1997	1998	1999	2000
OPERATING (NIDA & BNL)	0.3	0.3	0.3	0.3	0.3
CAPITAL (ONDCP)	0.5	0.9	0.4	0.0	0.0
TOTAL	0.8	1.2	0.7	0.3	0.3

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
KP BIOLOGICAL & ENVIRONMENTAL RESEARCH								
Operating	27.1	26.6	37.3	38.0	38.0	38.0	38.0	38.0
Capital Equipment	3.9	0.9	3.9	2.9	2.9	2.9	2.9	2.9
Construction								
Life Sciences Support Facility (c)	--	--	--	--	1.3	11.4	--	--
Hot Lab Addition for PET(c)	--	--	--	--	0.5	3.2	--	--
Total Construction	0.0	0.0	0.0	0.0	1.8	14.6	0.0	0.0
Total Cost	31.0	27.5	41.2	40.9	42.7	55.5	40.9	40.9
Direct Personnel	144	142	176	182	182	182	182	182

(c) Proposed
* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

UNIVERSITY AND SCIENCE EDUCATION (KT)

Laboratory and Science Education Centers (KT-01)

The Office of University and Science Education Programs supports a number of education and training activities at BNL. Details of these programs are described in Section V.F Here we briefly review the major programs.

Several programs for high school students and teachers now disseminate science content through courses and short programs or provide training in research. BNL has offered in-service courses for teachers since 1958 - the current topic is environmental science. Summer research placements for high school teachers began in 1984. A Community Summer Science Program (CSSP) presents an overview of cutting edge science to high school students and teachers. A High School Summer Apprenticeship Program (MHSAP) and academic year mini-semesters provide opportunities for minority students.

Programs for the lower grades, such as the Elementary Science Fair, Jr.H.S. Science Explorations and Exhibit Center/Science Museum tours, the Bridge Building Contest, a MAGLEV Contest, and Introduction to Computers generally promote science in local schools or communities. Several activities target minorities and women, supported by partnerships with schools and community agencies.

BNL's Five Year Science Education Plan established the thrust of many initiatives. Areas targeted include: 1) science and technology education for minorities; 2) technical education to reach "average" or disadvantaged students; 3) science and technology education for the disabled; and 4) resources for providing technical assistance to the educational community. These remain the major thrusts of the program.

Increased emphasis has been placed on precollege education within the areas already targeted, and on precollege teacher enhancement.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
KT UNIVERSITY AND SCIENCE EDUCATION								
Operating	2.0	0.7	1.2	1.5	1.5	1.5	1.5	1.5
Direct Personnel	7	6	6	6	6	6	6	6

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

MAGNETIC FUSION (AT)

Development and Technology (AT-15)

Commercially available Nb_3Sn composite wires are being examined in support of the ITER (Tokamak) project. Improved critical currents at high magnetic fields is the research goal. Support is also directed toward the U.S. Fusion Program.

The National Nuclear Data Center satisfies several special nuclear data requirements of the magnetic fusion energy program by critical evaluation of existing experimental data and estimation of other data using nuclear theory.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
AT-15 DEVELOPMENT & TECHNOLOGY (MAGNETIC FUSION)								
Operating	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1
Direct Personnel	1	-	1	1	1	1	1	1

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

CONSERVATION AND RENEWABLE ENERGY

ELECTRIC ENERGY SYSTEMS (AK)

Systems and Materials Research (AK-06)

Two new tasks continue to be investigated in order to take advantage of recent discoveries of super-conducting compounds with high critical temperatures (T_c). The first task involves investigations of various methods for fabricating composite conductors, including those containing high-T_c oxides. The methods to be employed will be restricted to those which lend themselves to being scaled up to pro-duce long lengths of conductor. Metallurgical and superconducting property characterization will be utilized as guides to producing improved and practical conductors.

The second task addresses the effects of conductor configuration on stability, ac losses and operat-ing temperature in high-temperature superconducting devices. The research effort focuses on the impact of temperature variation on operating characteristics, and the effect of processing procedures such as rough tape edges on ac losses. In addition, practical aspects of gas-cooled device operation are being studied.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
AK ELECTRIC ENERGY SYSTEMS								
Operating 0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
Direct Personnel	2	2	2	2	2	2	2	2

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

GEOTHERMAL SYSTEMS (AM)

Geothermal Technology Development (AM-10)

The elements of this program are to develop high temperature well cements, lost circulation control materials, nonmetallic materials such as elastomers, plastics, and polymer concretes, and pitting resistant alloys for use in geothermal processes. Subprograms include in-house R&D, subcontracted R&D, technology transfer efforts, and the organization of workshops, cooperative testing, and setting of standards with foreign geothermal developers. The goal is low cost, corrosion resistant materials which can be used in components such as pumps, drill bits, casings, drill pipes, heat exchangers, vessels, and collection piping.

Biochemical processes for detoxification of residual brines and related by-products from Geothermal Power Production is under development. Concurrently, processes for the recovery of metals, salts and other commercially viable products are also being interphased with the overall advanced

biochemical technology for geothermal brines. The overall process has been shown to be economically feasible and environmentally acceptable.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Year)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
AM GEOTHERMAL SYSTEMS								
Operating	0.2	1.3	1.5	1.5	1.5	1.5	1.5	1.5
Capital Equipment	--	0.1	0.1	0.2	0.1	0.1	0.1	0.1
Total Cost	0.2	1.4	1.6	1.7	1.6	1.6	1.6	1.6
Direct Personnel	1	9	10	10	10	10	10	10

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

SOLAR ENERGY (EB)

Photovoltaic Energy Systems (EB-22)

The U.S. Department of Energy (DOE), Office of Utility Technologies, Photovoltaic Energy Technology Division is supporting research to develop new and more efficient photovoltaic material, process, and application options. In order to aid in the assessment of EH&S problems, the DOE PV program established the Photovoltaic Environmental, Health and Safety (EH&S) Assessment Program at Brookhaven National Laboratory (BNL). The purpose of this program is to identify and examine potential health and safety barriers, and hazard control strategies for new photovoltaic material, process, or application options before their large-scale commercialization. To ensure the successful transfer of data developed during these research efforts, a Safety Assistance Center has been establish-ed to provide direct and focused EH&S information to researchers and managers in the photo voltaics community.

Specific support to be provided to DOE, DOE contractors and the private sector will take many forms including: preparing technical reports, cohosting workshops, leading accident investigation teams, initiating cooperative program with other agencies and organizations, and assisting the National Renewable Energy Laboratory and Sandia National Laboratory manage hazardous materials used in photovoltaic module manufacture.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
EB SOLAR ENERGY								
Operating	0.4	0.3	0.3	0.4	0.4	0.4	0.4	0.4
Direct Personnel 2	2	2	2	2	2	2	2	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

BUILDINGS SECTOR (EC)

Heating and Cooling Equipment (EC-23)

The goal of this program is to reduce the amount of oil and gas used to heat residential and com-mercial buildings. Emphasis is placed on research that will assist the industry to develop and/or adopt more efficient products and methods, but which the industry is not expected to perform on its own. These areas include: direct improvement of seasonal efficiency (e.g. condensing systems); reduced risk of efficiency degradation over time (e.g. sooting in oil-fired equipment); auxiliary systems that will permit or encourage the use of efficient heating equipment (e.g. direct venting); and reduction of energy losses in the duct or piping systems that carry the heat to the conditioned space.

Building Technologies (EC-27)

A program of educational and training activities in the building sector has the potential to address a number of market barriers associated with underutilized energy efficiency measures. Post-construction, building owners and operators often minimize O&M budgets because their economic benefits are not known. Partnering with state energy offices, utilities, and trade groups, the program will implement training programs and training packages and monitor the results for program effectiveness.

Building Systems Integration/Evaluation and Planning (EC-28)

Building systems integration will draw upon the separate areas of building science to analyze, develop, or test examples of energy-efficient residential and small commercial buildings that have been developed under DOE or industry auspices. Significant technical input to the design from the BNL research team is anticipated.

The evaluation and planning activity provides technical support to assist the Office of Building Technologies (OBT) to structure its program to achieve, in the minimum feasible time and with effective use of resources, DOE's energy efficiency and renewable energy objectives for the buildings sector. This will include preparation of strategic and multi-year plans, program prioritizations, reviews of goals and objectives, evaluation of R&D impacts, assistance in development of the analysis plan and analysis integration, and preparation of an annual summary report of OBT analyses.

PROGRAM SUMMARY ($ in Millions in Budget Authority) (Personnel in FTE) (Fiscal Years)								
	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
EC BUILDINGS AND COMMUNITY SYSTEMS								
Operating	1.4	1.4	0.9	1.4	l.3	1.3	1.3	1.3
Capital Equipment	--	--	0.1	--	0.1	0.1	0.1	0.1
Total Cost	1.4	1.4	1.0	1.4	1.4	1.4	1.4	1.4
Direct Personnel	8	7	8	8	8	8	8	8

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

TRANSPORTATION (EE)

Alternative Fuels Utilization (EE-50)

This program addresses the problems of introducing Alternative Fuels into the transportation energy sector. Fuels under consideration are methane, methanol and hydrogen. Studies involve natural gas adsorbents, most notably activated carbons, in order to develop adsorbents which clearly outperform compressed gas storage systems. This work is followed by engineering development of the storage tank and low cost catalysis system for emission control. The remaining task is to integrate this federal program with the ongoing activities at the Gas Research Institute (GRI) with the automotive industry, and with the adsorbent manufacturers so as to promote and exchange this technology in a timely fashion.

Electric/Hybrid Propulsion Division (EE-53)

This program addresses problems related to batteries and fuel cells for electric and hybrid vehicles. Studies have been undertaken to better understand electrocatalysis on a molecular level and apply this knowledge to technology base development of new materials and novel concepts for fuel cells. The information will be used to tailor new and less expensive catalysts for direct methanol fuel cells. Work is also being done on the structure and characterization of battery materials using facilities at the NSLS and HFBR. These facilities will also be used to study materials related to metal hydrides and lithium batteries.

RESEARCH INITIATIVE

Transportation Sector Technologies

In conjunction with DOE-CE, the DOT, EPRI, FAA, and others, it is proposed to undertake a new initiative to address research needs associated with the technologies associated with the transportation sector.

Specific topics include:

modeling of emissions from various fuel source/vehicle mixes
synthesis of alternate fossil fuels

ITS technologies evaluation
materials applications
public risk prediction

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
EE TRANSPORTATION								
Operating	0.6	1.5	1.2	1.1	1.1	1.1	1.1	1.1
Direct Personnel	2	4	6	6	3	3	3	3

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

ENVIRONMENT, SAFETY AND HEALTH

The U.S. DOE, Office of Environment, Safety and Health, has been involved in the development and implementation of a comprehensive management, organization, and personnel program to improve the safety performance of individuals, human systems (e.g., management), and organizations, and their interactions with technical systems. In attempting to institutionalize consideration of human performance and reliability issues in all facets of facility/equipment design, construction, operations, maintenance, and decommissioning, one approach is to enhance current evaluations and assessments by providing technical support in human performance areas. BNL is providing that support, in particular to DOE Headquarter's assessments, in the development of human performance objectives and criteria to be integrated with existing performance objectives and criteria, and in procedures and/or tools for the appraisal of human performance. In addition, BNL is supporting the EH Mentoring Assistance Program to empower field personnel and help improve safety.

ENVIRONMENTAL RESEARCH AND DEVELOPMENT (HA)

Overview and Assessment (HA-01)

The BNL As Low As Reasonably Achievable (ALARA) Center staff members are actively assisting in the Defense Program's (DP) Mentor Program. One staff member is chairing the Vault Upgrade Task Force at Los Alamos National Laboratory's (LANL) TA-55 plutonium facility and supporting the Radiation Dose Reduction Program at the Special Nuclear Material (SNM) storage vault.

Staff members are also acting as mentors to the professional staff at the ESH-12 ALARA Team office. In the future, staff will visit other DP sites and make recommendations to reduce dose and provide advice and assistance on occupational ALARA programs.

We are providing support to DOE in the development and implementation of a comprehensive management, organization, and personnel program to improve the safety performance of individuals, human systems, and organizations, and their interactions with technical systems. BNL is assisting DOE in its efforts to monitor,

audit, and assess the effectiveness of implementing DOE non-nuclear and occupational safety and oversight programs including resolution of safety issues. A line safety docu-mentation database will be established to aid in these functions. BNL will maintain the capability to assess effective dose equivalents to populations or individuals from internally deposited radionuclides. We continue to address the exposure and risk associated with implementing proposed regulations for radionuclides in drinking water. This will include a bioassay campaign utilizing the fission track analytical method for plutonium-239. BNL publishes a risk analysis newsletter quarterly that collects and integrates information from all of DOE as well as pertinent information from outside of DOE.

BNL will provide process safety management (PSM) review services designed to assist EH-30 in its responsibility for the safe management of highly hazardous chemicals (HHC) at DOE facilities and conformance with the Occupational Safety and Health Administration's (OSHA) PSM Rule.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
HA-01 ENVIRONMENT, SAFETY AND HEALTH								
Operating	1.6	1.3	2.6	2.1	1.6	1.6	1.6	1.6
Capital Equipment	--	--	0.4	--	--	--	--	--
Total Cost	1.6	1.3	3.0	2.1	1.6	1.6	1.6	1.6
Direct Personnel 9	5	9	8	8	8	8	8	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

EPIDEMIOLOGIC ACTIVITIES (HR)

Epidemiologic Activities (HR-01)

A radiological safety program is maintained for inhabitants of atolls in the Northern Marshall Islands. Analyses of excreta are performed for residents of Rongelap, Bikini, Utirik, and Enewetak Atolls. Whole-body counting is performed in the field as required, and bioassay techniques are used to assess internal doses from fallout radionuclides. A screening and sampling protocol is being developed and implemented based on fission track analyses using high performance liquid chromatography and inductively coupled mass spectrometry. This sampling protocol will include both returning and non-returning dri-Rongelap, dri-Bikini, and other peoples. A database is being maintained on up-to-date information concerning background and subsequent fallout radionuclides in Marshallese subjects.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
HR-01 EPIDEMIOLOGIC ACTIVITIES								
Operating	1.8	1.8	1.8	1.8	1.5	1.5	1.5	1.5
Capital Equipment	0.2	0.1	0.2	--	--	--	--	--
Total Cost	2.0	1.9	2.0	1.8	1.5	1.5	1.5	1.5
Direct Personnel	9	10	9	9	8	8	8	8

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

NUCLEAR ENERGY

NUCLEAR ENERGY R & D (AF)

Light Water Reactors (AF-11)

BNL is completing the program of assisting DOE in assessing severe accidents for Advanced Light Water Reactors (ALWR). The work involved the analysis of postulated molten core-concrete inter-actions in the CE System 80+ basemat to assess containment performance using the CORCON computer code. In addition, BNL has a lead in assessing human factors aspects of advanced control rooms and their impact on safe operation.

Gas Turbine-Modular High Temperature Reactor (GT-MHR)(AF-95)

BNL is providing support to the DOE in reviewing and evaluating existing GT-MHFR (Gas Turbine-Modular High Temperature Reactor) fuel work and proposed future fuel development in both DOE supported program and in GT-MHR fuel programs in foreign countries. The tasks include providing assistance to the DOE contractors in helping understand the causes and mechanisms involved in fuel failure and to offer suggestions for improved fuel performance.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
AF NUCLEAR ENERGY R&D								
Operating	0.1	--	--	--	--	--	--	--
Direct Personnel 1	--	--	--	--	--	--	--	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

NUCLEAR ENERGY

Nuclear Safety, Policy and Standards (HP-01)

BNL has established a Nuclear Safety Support Group (NSSG) for the purpose of assisting the Department of Energy (DOE) in areas related to nuclear safety policy and standards applicable to DOE nuclear facilities. During FY95 the DOE Orders have undergone substantial streamlining under the Secretary's Directive Improvement Initiative. In FY96, DOE is focusing a similar level of effort on codifying performance based nuclear safety rules. The NSSG will continue to assist the DOE Office of Nuclear Safety, Policy, and Standards in developing safety guides and standards to imple-ment the nuclear safety rules and orders at DOE facilities.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
HP-01 NUCLEAR SAFETY POLICY								
Operating	0.9	0.6	0.9	0.9	0.6	0.6	0.6	0.6
Direct Personnel	3	2	2	2	2	2	2	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

ISOTOPE PRODUCTION AND DISTRIBUTION PROGRAM (ST)

Isotope Production (ST-01)

This effort is an outgrowth of our Office of Health and Environmental Research supported program, "Radionuclide and Radiopharmaceutical Research for Medicine", (KP-06-01, MO-11). Production and distribution of radioisotopes have been separated from the OHER program in response to recent DOE policy. The purpose of this project, thus, is to use the Brookhaven Linac Isotope Pro-ducer (BLIP) and the associated Hot Laboratory to prepare and distribute to the nuclear medicine community and industry some radionuclides that are difficult to produce. This effort entails 1) target fabrication and testing; 2) irradiations; 3) radiochemical processing by remote methods in hot cells; 4) quality control and analysis; 5) waste disposal; 6) equipment maintenance; and 7) customer liaison, marketing, packaging and shipping. Service irradiations (without chemistry) are also accommodated if they are compatible with the primary isotope production.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
ST ISOTOPE PRODUCTION AND DISTRIBUTION PROGRAM								
Operating 0.8	1.2	1.0	1.0	1.0	1.0	1.0	1.0	
Capital Equipment	0.2	0.3	0.1	0.1	0.1	0.1	0.1	0.1
Total Cost	1.0	1.5	1.1	1.1	1.1	1.1	1.1	1.1
Direct Personnel 3	4	3	3	3	3	3	3	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

DEFENSE

PROGRAM DIRECTION (GB)

Accelerator Production of Tritium (GB-06)

Brookhaven National Laboratory (BNL) has been involved in the Accelerator Production of Tritium (APT) project since ~1988. The major elements of the APT concept are: 1) a high-powered (currently 130 MW of beam power) proton linear accelerator operating in "continuous-wave (CW) mode"; and 2) a target system which generates neutrons via proton-induced spallation reactions in a heavy metal target (e.g., tungsten, lead), and subsequently captures the neutrons in a suitable "feedstock" (typically helium-3 gas, or solid lithium-aluminum) to produce tritium. In the APT concept, tritium is produced without the presence of fissionable materials; therefore, no high-level waste is produced, and the ES&H concerns are significantly reduced compared to reactor systems. The program is designed to produce tritium in the ~2005-2011 time-frame.

The concept has been developed primarily by a team of national laboratories which includes Los Alamos National Laboratory (LANL), BNL, Sandia National Laboratory (SNL), and Lawrence Livermore National Laboratory (LLNL). Industrial partners have also contributed to the design efforts. In FY93 and FY94, the team developed a pre-conceptual design for the APT system, includ-ing designs for the LINAC, target systems, and Balance-of-Plant (BOP). Beginning in FY95 the program has been led and managed by an APT Project Office at LANL. The near-term focus of the program is an Engineering Design/Technology Demonstration program in preparation for a Record of Decision (ROD) scheduled for 1998. At that time, the next tritium production technology will be selected from between the APT concept, and an option based on the use of a commercial Light-water reactor (LWR).

BNL's role in the program expanded in FY96 to include accelerator-related activities (e.g., magnet design, examination of the superconducting option), in addition to target-related efforts such as design, safety and supporting physics and materials experiments, and systems studies of reliability and avail-ability. In the target area, BNL is currently supporting the design effort for the baseline target (which utilizes tungsten and helium-3 gas for the production of neutrons and tritium, respectively), and continues to examine options based on the lithium-aluminum technology used at Savannah River Site (SRS); the use of lithium-aluminum has been the basis for several designs developed by BNL earlier in the program. It is expected that BNL will continue to be an active

participant/partner in the program by contributing technical staff expertise, and facility (e.g., AGS, BLIP, materials examination) support to the APT team.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
GB PROGRAM DIRECTION								
Operating	1.9	--	0.9	0.9	0.9	0.9	0.9	0.9
Capital Equipment	--	--	--	--	0.1	0.1	0.1	0.1
Total Cost	1.9	--	0.9	0.9	1.0	1.0	1.0	1.0
Direct Personnel	10	--	1	1	1	1	1	1

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

VERIFICATION AND CONTROL TECHNOLOGY (GC/GJ)

Assistance is being provided to the DOE Office of Nonproliferation and National Security in the identification, evaluation, and development of new technologies and methodologies for (1) the verification of arms control treaties and agreements, both bilateral and multilateral, and (2) the detection of activities indicative of nuclear weapons proliferation.

Arms Control Technical Analysis (GC-01)

BNL provides technical analysis support to the International Policy and Analysis Division of the Office of Arms Control and Nonproliferation. BNL provides technical and analytical support in a broad range of arms control areas including participation in negotiations for the U.S.-Russian Plutonium Production Reactor Shutdown Agreement, scope and verification option formulation, compliance determination, and treaty/agreement implementation. BNL is playing a major role in providing technical support to the U.S. DOE in preparing for negotiation and eventual implementation of the Special Nuclear Materials Production Cutoff Convention, one of several U.S. Nonproliferation Initiatives announced at the UN in September 1993. Activities include: development of scope language for the treaty; addressing verification options including inspections at undeclared sites; consideration of traditional and new IAEA safeguards approaches; development of implementation strategies for affected DOE facilities; estimation of inspection resource requirements; and preparation of a negotiator's handbook for U.S. members of the Delegation to the Conference on Disarmament (CD) in Geneva.

Arms Control Research and Development (GC-01)

BNL carries out research and development of systems and technologies for arms control verification and monitoring under the DOE Office of Research and Development (NN-20) of the Office of Nonproliferation and National Security. This program, originally initiated under the DOE Office of Arms Control, has been concerned with research and development efforts aimed at treaty verification and monitoring applications. An early effort was the origination of a system for verifying sensitive treaty limited items (for example, nuclear warheads) while controlling intrusiveness. Work in this area has resulted in development of a high resolution gamma spectrometer which may be used in verifying the presence of a warhead but without divulging classified information to the inspecting party. A novel technique has been developed to accurately determine the age of highly-enriched uranium (HEU) as a means of assuring its origins in connection with weapons dismantlement. Other work has involved the development of sample identification and remote detection of chemicals and substances indicative of nuclear weapon proliferation. The techniques being investigated include photoacoustic spectrometry, gamma-ray detector development, thermal neutron imaging, resonance Raman spectroscopy, and isotopic trace analysis methods and resonance neutron capture spectroscopy.

Chemical Analysis by Laser Interrogation of Proliferation Effluents (CALIOPE)(GC-04)

BNL is a key participant in a major cooperative activity identified as the CALIOPE project which addresses national security concerns. The CALIOPE project is a calibration between five national laboratories (BNL, LANL, LLNL, PNNL, and SNL) which will develop and demonstrate laser-based systems for remote optical detection and characterization of chemical effluents from proliferation activities. It began with laboratory experiments, field experiments, and advanced technology develop-ment and will culminate in proof-of-concepts demonstrations. The BNL contribution to the CALIOPE program is the development of a Remote Resonance Raman Spectroscopy Program. The aim of the Remote Resonance Raman Spectroscopy program is to investigate alternatives to conventional methods for both long range monitoring of effluents and local monitoring of chemicals and environmental samples. Raman scattering is a coherent, inelastic, two-photon process, which shifts the frequency of an outgoing photon according to the vibrational structure of the irradiated species, thereby providing a unique fingerprint of the molecule. Unfortunately, the inherently small scattering cross-sections for *normal* Raman spectroscopy effectively limited the use of this technology outside of the lab. How-ever, when the excitation frequency approaches an electronically excited state of the molecule, an enormous enhancement of the scattering cross-section can occur, often up to 4 to 6 orders of magnitude, and is referred to as *resonance* Raman (RR), since the excitation frequency is in "resonance" with an allowed electronic transition. This improvement in the scattering cross-section can now be routinely realized because of the recent advances in frequency tunable, all solid-state laser systems. When these state-of-the-art laser systems are used with a remote detection of toxic or proliferation-related chemicals, hazardous wastes, atmospheric pollutants and biologicals becomes available.

Brookhaven National Laboratory has recently applied this technology to the detection of ppm concentrations of sulfur dioxide (SO_2) and other chemicals at stand-off distances approaching 1.5 km. BNL accomplished this using an interim system that consisted of a 30" Cassegrain telescope system, a frequency tunable, all solid-state laser with a nominal pulse energy of 3-5 mJ at 300 nm, and a customized knife-edge filter/single-grating spectrometer/ICCD sub-system. All instruments and equipment were housed in BNL's 48' x 8' x 13' trailer. Using the return signals from atmospheric nitrogen and oxygen, in conjunction with the known atmospheric concentration of these two species,

the calculated SO_2 concentration, based upon its resonance Raman cross-section and the return signal strength, was within 15% of that measured with mass flow meters in the wind tunnel. The overall system accuracy, based on concentration measurements of atmospheric N_2 and O_2 was found to be < 10%. Also, an initial effort by BNL staff using neural networks for pattern recognition on the data collected has resulted in a 93% accuracy of differentiating the SO_2 return signal from background noise. Efforts at BNL are now centered on preparing for the replacement of the 30" Cassegrain telescope with a 1.25 meter Cassegrain, upgrading the MOPO laser in order to achieve higher repe-tition rates and pulse energies, optimization of the uniaxial optical configuration and other numerous upgrades in the areas of instrumentation control, data processing and analysis.

RESEARCH INITIATIVE

Industrial Partnerships with the Newly Independent States of the Former Soviet Union

President Clinton signed the Fiscal Year 1994 Foreign Operations Appropriations Act (P.L. 103-87) on September 30, 1993. Section 575 of the Act contains provisions to establish "a program of cooperation between scientific and engineering institutes in the New Independent States of the Former Soviet Union and national laboratories and other qualified academic institutes of the United States"... The Act appropriates funds for partnerships involving U.S. industry, universities, DOE National Laboratories, and key New Independent States (NIS) institutes. The partnerships "are designed to stabilize the technology base in the cooperating states," and "prevent and reduce proliferation of weapons of mass destruction". Stabilization element provides immediate funding to the NIS institutes in support of US nonproliferation goals. NIS institutes and US national laboratories will develop technologies appropriate for commercial-ization. This element builds on existing collaborations between laboratories and institutes; it uses established procedures and existing authority. DOE and the Department of State have provided policy guidelines for selection of the projects by the DOE National Laboratories. Projects are reviewed by an Inter-Laboratory Board (ILAB) before being forwarded to DOE and the Department of State. ILAB has representatives from ten DOE National Laboratories, and is the coordinating body and operations center for laboratory activities.

International Safeguards (GJ-04)

BNL provides technical and analytical support to the International Safeguards Division of the Office of Arms Control and Nonproliferation in the DOE Office of Nonproliferation and National Security. BNL's support to the DOE International Safeguards Division includes a variety of projects relating to preparation for IAEA inspection of U.S. uranium enrichment facilities and support to DOE in bilateral safeguards cooperation with Japan, Argentina and the joint Argentine-Brazilian Safeguards Inspectorate (ABACC).

RESEARCH INITIATIVE

US/Former Soviet Union (FSU) Nuclear Materials Safeguards Cooperation

Cooperative Tasks between the US and Russia on Nuclear Material Protection, Control and Accounting funded by DOE and the Department of Defense through the Defense Nuclear Agency (DNA).

BNL provides assistance to the DOE Office of Arms Control and Nonproliferation for two programs of cooperative tasks between the US and Russia on nuclear Material Protection, Control and Accounting (nuclear MPC&A): (1) Laboratory-to-Laboratory and (2) Government-to-Government. BNL provides one of the six members to each Steering Group for these separate programs. Also, BNL participates in the US project teams which plan for, work on and monitor tasks with specific Russian institutes and enterprises. In addition, BNL provides project management for selected cooperative projects and technical and analytical support for specific tasks.

Under the Laboratory-to-Laboratory program, BNL provides assistance to the DOE Office of Arms Control and Nonproliferation to enhance, through US-Russian technical cooperation, the effectiveness of nuclear MPC&A in Russian nuclear facilities and enterprises that process or store highly enriched uranium or plutonium. The enhancements are implemented by the Russian institutes and enterprises using both US and Russian equipment and methods. BNL provides funding for the Russian institutes through Lab-to-Lab contracts and shares technical information and experience from the applications of MPC&A methods and technologies.

The Government-to-Government program is part of a broader program of Cooperative Threat Reduction between the US and Russia. Under the Government-to-Government program, BNL assists DOE in fostering bilateral cooperation in nuclear MPC&A matters and provides training, design consultation, equipment and other support to the Russian facilities as agreed upon by the Russian Ministry of Atomic Energy (MINATOM) and DOE. In the case of equip-ment selected by a participating Russian institute or enterprise, BNL channels specific DOE-approved funds to the US commercial vendor or to the Russian parties for the manufacture or purchase of the equipment. BNL also provides assistance to the DOE Office of Arms Control and Nonproliferation for cooperative tasks with the Federal Nuclear and Radiation Safety Authority of Russia (Gosatomnaddzor).

Reactor and Safety Assistance to Russia/Ukraine

The International Nuclear Safety Program (INSP) within the DOE Office of Nuclear Energy provides for the comprehensive improvement in safety culture, power plant operation and physical condition, and infrastructure in countries operating Soviet-designed reactors. This objective is achieved by:

- cultivating an attitude towards nuclear safety approaching that existing in Western countries;
- developing and installing equipment and methods which will improve the safety of operations, with emphasis on RBMKs and VVER 440/230s.;
- incorporating the owners and operators of Soviet-designed nuclear power plants as full partners in the global nuclear industry; and
- enhancing indigenous capability to evaluate safety and make decisions about shutdown.

BNL has been assisting NE-15 for over two years, principally in the areas of training, simulators (both full-scope and analytical), certain safety system upgrades, and technology transfer. This program is continuing to experience moderate growth as the INSP projects evolve.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
GC/GJ VERIFICATION AND CONTROL TECHNOLOGY								
Operating	6.5	13.0	16.4	15.7	15.6	15.6	15.6	15.6
Capital Equipment	0.7	0.4	1.8	2.0	0.7	0.5	0.5	0.5
Total Cost	7.2	13.4	18.2	17.7	16.3	16.1	16.1	16.1
Direct Personnel	31	26	33	35	34	34	34	34

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

NUCLEAR SAFEGUARDS AND SECURITY (GD)

Nuclear Materials Safeguards and Security (GD-06)

BNL assists the DOE Office of Safeguards and Security in extending the Science and Technology Base that supports the Nuclear Safeguards and Security requirements of the DOE complex. Current activities include the following projects: A system which will measure and store the gamma-ray spectrum of an SNM-containing item and compare the stored spectrum with the time-dependent spectrum measured at some later time is being developed as a material control measure. A short term objective of this program is to develop and demonstrate a measurement method which will confirm the presence of all special-nuclear-material parts in assembled nuclear devices when they are returned to custody of the Department of Energy, thus providing immediate assurance that no special nuclear material has been lost of diverted. A high-resolution, xenon gas-filled gamma-ray spectrometer which operates at ambient temperatures is being developed for material surveillance and material accounting applications. Neutron coincidence counting is a standard and widely used non-destructive assay technique for uranium- and plutonium-containing nuclear materials. In previous work for support of international safeguards, BNL had developed improved algorithms for quantitatively determining the amount of uranium or plutonium from the neutron coincidence counting rate and for generating quantitative limits for the range of measurement uncertainty. The BNL algorithms are believed to be more generally applicable to a variety of materials with widely varying neutron-multiplying and moderating characteristics without the need for recalibra-tion with well characterized materials closely resembling each type of material being measured. A program has been initiated to field test the BNL algorithms with instruments available at other Department of Energy facilities. BNL is acquiring an active-well coincidence counter and will use it to assay difficult-to-measure materials at other facilities. These projects are expected to progress to the concept and demonstrational phase.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**

GD NUCLEAR SAFEGUARDS & SECURITY

Operating	0.5	0.6	1.8	1.5	1.2	1.0	1.0	1.0
Capital Equipment	--	0.1	--	--	--	--	--	--
Total Cost	0.5	0.7	1.8	1.5	1.2	1.0	1.0	1.0
Direct Personnel	3	3	5	5	5	5	5	5

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

WEAPONS STOCKPILE MANAGEMENT (DP)

Technical Assistance to Savannah River Operations (DP-04)

BNL assists the Security Management Division of the DOE Savannah River Operations Office with respect to ongoing and anticipated problems related to safeguards and security. Technical assistance is being provided for review of contractor-proposed material control and accounting (MC&A) procedures; for analysis of persistent problems with nuclear material balances at various Savannah River Site facilities; for accurate determination of solution volumes in process and storage tanks; for pre-paration of MC&A training materials and operation of training programs; for review and validation of upgrade projects for the MC&A program; and with preparation for international inspections of SRS facilities under various international agreements.

Defense Program Engineering, Operations, Security and Transition Support (DP-04)

BNL assists the DOE Office of Engineering, Operations, Security and Transition Support with analy-sis, verification, development and implementation of safeguards and security (S&S) programs and technology at Defense Programs (DP) facilities. These activities include review of Site Safeguards and Security Plans (SSSP), verification reviews for S&S projects and upgrades, technical studies related to deployment of S&S technology, development and/or review of S&S oversight plans for DOE field organizations, and review of S&S problems at DP facilities. S&S assistance is provided to support reconfiguration of the DOE complex, disassembly and disposition of material and components from nuclear weapons, transition of facilities from DP to the Environmental Management program, manage-ment of radiological and toxicological sabotage concerns, and protection of nuclear materials for which the Department of Energy is responsible.

Human Performance Improvement Program (DP-04)

The DOE has identified human performance to be an important area that can lead to improved facility safety. This broadly focussed program will develop and apply evaluation methods for

assessing the attributes that contribute to enhanced human performance. Attributes involving management, organization, and individual performance have been identified; survey and appraisal techniques formulated and tested; and field applications are ongoing. Efforts will continue in developing and using the evaluative techniques, but will also encourage Operation Office and DOE contractor involvement for the purpose of understanding the safety principles identified by the program and for the direct implementation of improvements in the field.

Training and Safety Documentation (DP-04)

BNL provides assistance to the DOE, Office of Defense Programs (DP) in the assessment, development, and performance of Technical Engineering training for both Headquarters and field staff.

BNL also provides on-call assistance in the review of safety-related documentation [Safety Analysis Report (SAR), Technical Safety Review (TSR), Justification for Continued Operation (JCO), Standard Review Plan (SRP) and Unresolved Safety Questions (USQ)].

Nuclear Systems Engineering Support (DP-04)

BNL provides technical assistance and subject matter expertise, as requested, in all technical areas relating to DOE production, research and development, and health and safety; and presentation of training programs. This work will utilize subject matter experts with demonstrated maturity, know-ledge of the DOE operations, experience with facility system operations, and expertise in one or more of the following types of technical areas: maintenance programs, radiological controls, health physics, fire protection, industrial hygiene, occupational safety, construction and construction safety, emergency preparedness, equipment qualification, industrial hygiene, nuclear criticality safety, operations, quality assurance (verification), reactor safety, seismic engineering, structural analysis, thermal hydraulics, training and certification, waste management, auxiliary safety systems, emergency power systems, ventilation systems, mechanical design and installation, instrumentation and controls, work-place control, and electrical safety, and other technical matters of similar nature.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
DP WEAPONS STOCKPILE MANAGEMENT								
Operating	3.2	6.2	6.2	8.3	7.0	6.0	6.0	6.0
Direct Personnel 13	21	23	24	17	13	13	13	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT (EX/EW)

A vast amount of nuclear and chemical waste materials was generated in the last 50 years in order to meet the national security and research needs. Some amount of this waste has already contaminated the environment and the remaining amount is contained in aging facilities and awaiting further treatment for disposal. There is also a vast stockpile of unused nuclear materials and spent nuclear fuels most of which require immediate attention because of their current conditions. In its mission to manage these waste problems and restore the environment, DOE-EM is encountering an enormous technological gap to deal with these issues. BNL, along with other laboratories (e.g., LANL and PNL) and contractors, is providing the needed scientific and engineering skills to

remedy the immediate hazards and plan for long-term cost-effective, reliable and environmentally-sound stabilization and disposal schemes. BNL participation in this national program includes studies of chemical and nuclear processes; examination of the scientific aspects of the hazards; research work on stabilization, remediation and disposal plans; and providing expert services in addressing safety issues and implementing programs. The following are examples of BNL's efforts as they pertain to various DOE-EM offices.

Waste Management (EX/EW-30)

The clean-up of roughly 100 million gallons of high-level radioactive waste stored in large underground tanks over a period of 30-50 years, along with cesium and strontium capsules, and estimated to cost about 100 billion dollars is by far the most ambitious and expensive program for DOE-EM. BNL staff have joined a national team and are examining the waste chemistry and physical conditions; studying the root causes of potential chemical explosion hazards; reviewing safety measures; developing analytical formulas for dynamic loads and guidelines for seismic analysis; examining aging mechanisms and developing guidelines for structural integrity and for in-service inspection; using system engineering approach to integrate numerous processes such as storage, retrieval, pretreatment and vitrification; and providing recommendations to DOE for safe and cost-effective measures.

A most visible and critical safety concern in the DOE complex is the generation, retention and sudden release of large volumes of hydrogen gas in the dome space of a tank, creating potential for deflagration. BNL staff have examined the possible scientific reasons for the gas generation and mechanisms; studied options for immediate mitigation; reviewed safety risks; and participated in implementing a highly-instrumented mitigative experiment requiring slow mechanical mixing of the waste. Many other tanks retaining hydrogen gas are currently being studied.

BNL is developing structural and seismic guidelines for evaluation of the underground steel and concrete tank structures. Starting with the fundamental principles, formulas for analytical solutions are being developed. The uniqueness of these structures and inadequacies of existing national standards in designing and analyzing such structures are being addressed.

BNL is evaluating the aging mechanisms that could be of concern for the structural materials in the tank physical and chemical environments. Studies identified only a very few mechanisms that could cause material degradation and eliminated many others as being nonsignificant. The generic thermal effects on concrete have been quantified.

The Secretary has appointed a top-level committee to evaluate integration of system engineering processes for the clean-up operation including retrieval, separation, vitrification and disposal of waste. BNL staff serve on this committee as the leaders of the technical and integration teams, and provide expert services.

Environmental Restoration (EX/EW-20)

BNL is applying generic PRA methodology to assessing the performance of DOE high-level waste disposal sites to an acceptable level of confidence. Studies are also being done to apply realistic risk assessment techniques to radiological and hazardous waste sites at DOE facilities. Risk of radon and contamination of drinking water from uranium mill-tailings piles is being assessed, and cost-effectiveness of mill-tailing clean-up efforts being calculated. Assistance is provided DOE on risk-based prioritization of environmental clean-up efforts.

Technology Development (EW-40)

The U.S. Department of Energy's Environmental Management (EM) Office of Technology Development (OTD) is currently sponsoring several programs at the BNL Department of Advanced Technology Environmental & Waste Technology Center. These programs support OTD's overall mission to develop new and innovative technologies to develop faster, better, safer, and cheaper solutions to DOE's environmental restoration and waste management problems. Development efforts are focused in three major problem areas: mixed waste, leaking waste storage tanks, and contaminated plumes. New technologies for improved treatment and disposal of radioactive, hazardous, and mixed wastes are being developed, tested, and demonstrated at production-scale for use within DOE and the commercial sector. State-of-the-art materials are being formulated and tested for use in constructing engineered barriers around leaking storage tanks and contaminated disposal sites and for the construction of the next generation of disposal facilities. This will minimize the formation of contaminant plumes for storage and disposal sites. Performance criteria and testing methods for evaluating pro-cessed waste products are being developed to enable the prediction of long-term performance under disposal conditions. The BNL Environmental & Waste Technology Center is working jointly with industry and academia to expedite technology development and provide an important contribution in helping DOE meet it's environmental challenges.

DOE programs are conducted on management of low-level radioactive and mixed waste to develop: 1) new solidification techniques; 2) encapsulation methods; 3) materials for subsurface confinement barriers around buried waste and 4) waste form performance criteria and testing methods for mixed waste.

A full-scale demonstration of the newly-developed polyethylene process for the encapsulation of chemical hazardous and mixed wastes will be accomplished in cooperation with a specific DOE waste generation site and commercial company that offers a system applicable to the simultaneous volume reduction and encapsulation of wastes with polyethylene.

Cleanup of environmental contamination at DOE facilities is estimated to cost multibillions of dollars. Usable estimates of potential health risks associated with this contamination are important to rational decision making on remedial action. This work will provide this needed information to DOE. The specific objective is to perform a pilot study of hazardous waste and contaminated sites at the Savannah River Project, the Nevada Test Site, and the Feed Material Production Center that will provide realistic estimates of potential health risks useful to decision making on remedial action at these sites and sufficient to demonstrate the usefulness of the approach at all DOE facilities.

BNL will perform self-assessments, oversight, testing, and analysis of Office of Technology Development programs. This includes establishing self-assessment and Laboratory management systems for DOE's waste management and environmental restoration programs. This task will provide: 1) a methodology for conducting line management assessments; and 2) provide information required to assess current sampling and analytical Laboratory process capabilities, specify data quality objectives, determine requirements for sample processing, and improve laboratory efficiency.

The DOE Office of Environmental Restoration and Waste Management expects to make use of commercial laboratories for analysis of mixed waste samples from restoration sites. BNL will assist DOE in preparing and implementing audit procedures to assure that these analytical laboratories are in compliance with applicable DOE health and safety requirements.

Brookhaven National Laboratory and the Long Island Research Institute (LIRI), in conjunction with the Department of Energy (EM), have formed the Northeast Waste Management Enterprise (NEWME) in response to the opportunity presented by the DOE's need to assist in the commercialization of new environmental and waste management techniques. Once commercialized, these techniques will be available to DOE for use at contaminated sites. LIRI plays a key role as coordinator of this initiative, and works closely with Brookhaven to establish an R&D network that includes the important centers of environmental expertise in the Northeast in academia and in the industrial sector. Com-petitive, effective solutions arrived at in the Northeast can form the basis of an accelerated remediation program for DOE site cleanups while promoting U.S. industries as leading purveyors of these new technologies.

Limiting Occupational Radiation Exposures (EW-70)

Recommendation 94-1 of the Defense Nuclear Facilities Safety Board to the Department of Energy (DOE), states that in implementing its recommendations due attention be given "to limiting worker exposure...". In response to this directive a proposal was made to the Office of Facility Transition and Management (EM-60), DOE for an integrated program to limit radiation exposures to workers. This project will include four major strands: (1) to collect information specific to DOE needs on innovative techniques to limit exposure to workers; (2) to have this information instantly available to all DOE facilities through on-line access; (3) using the experience gathered from previous work at several DOE facilities, to disseminate this experience within the DOE complex by acting as consultants, mentors, facilitators to the DOE contractors in general, and EM-60 in particular, as and when needed; (4) to follow up and to evaluate the additional needs of the DOE sites, of EM-60 and of the DOE, and to revise plans to incorporate these needs into the work of the EM-60 ALARA Project as appropriate.

Stabilization of Nuclear Materials (EW-70)

There is a large inventory of irradiated fuels from the production reactors as a result of the sudden decision to stop processing for plutonium. These spent fuels require stabilization without much delay. BNL staff are examining the degrading fuel canisters, formation of sludge and condition of the storage facilities. The staff are participating in evaluating the overall risk and assisting DOE in making decisions. Expert services are provided with options for stabilization. The staff are also participating in the DOE effort to stabilize the unused nuclear materials.

PROGRAM SUMMARY ($ in Millions in Budget Authority) (Personnel in FTE) (Fiscal Years)								
	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
EW/EX ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT								
Operating	25.0	33.3	32.1	30.6	30.6	30.6	30.6	30.6
Capital Equipment	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Construction	5.3	(0.3)	--	--	--	--	--	--
Total Cost	30.5	33.1	32.2	30.7	30.7	30.7	30.7	30.7
Direct Personnel	72	78	69	70	70	70	70	70
* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.								
** Constant FY1998 dollars								

FOSSIL ENERGY

Included are activities encompassing coal liquefaction, catalysis, advanced coal gasification and pyrolysis, combustion, fuel cells, systems analysis, coal slurry fuels, enhanced oil recovery, and bioremediation of oil spills. This area will deal primarily with advanced approaches to the increased utilization of coal. Project planning will, to some extent, depend on guidance from the Energy Technology Centers, as changes are made in program emphasis and budget level.

BNL proposes to develop the expertise necessary to investigate basic concepts and to develop advanced technologies for sustainable energy options. Technical expertise includes: 1) studies on advanced gas conversion, transport and storage systems, 2) new catalyst development for oxygenated fuels and fuel additives, 3) low temperature (<200 C) chemical heat pumps for capturing industrial waste heat and 4) CO_2 mitigation through utilization. The laboratory is assisted through international collaborations and has the necessary analytical instruments and test facilities to carry out its mission. In addressing catalyst development, a $1,000,000 state-of-the-art mini pilot test unit has been provided by Amoco under a CRADA with BNL. The unique unit has been designed for efficient performance evaluations of both homogeneous and heterogeneous catalyst systems with waste minimization being an inherent feature. Fuels of interest are natural gas and hydrogen as well as liquid fuels such as methanol, mixed alcohols and ethers. Emphasis is placed on homogeneous and fine particle liquid or slurry phase catalyst systems that offer low temperature fuel synthesis options.

COAL (AA)

Coal Utilization (AA-10)

A new program has begun in the area of indirect coal liquefaction, which goal is to evaluate and characterize fine particle catalysts for synthesis of higher oxygenates. Several projects presently funded through PETC are aimed at synthesis of isobutylene from non-petroleum sources. The BNL effort will utilize slurry phase operation in a CO_2 rich environment to maximize isobutanol production from synthesis gas. All catalytic materials will be characterized utilizing x-ray absorption fine structure (XAFS) and other analytical techniques available at BNL.

Combustion Systems (AA-35)

Research has begun directed to the application of condensing economizers to small coal-fired boilers and furnaces. Studies will include improvements in thermal efficiency, heat exchanger fouling, and the removal of particulates from the flue gas. The influence of water injection upstream of the economizer is an important part of this work. The project is intended to contribute to the ongoing Pittsburgh Energy Technology Center (PETC) program to develop coal-fired combustion equipment for commercial and residential applications.

A program was started to develop and analyze technologies to reduce CO_2 emissions from the use of coal. The process design will focus on the coprocessing of coal with natural gas and biomass. The MARKAL model will be used to determine the cost effectiveness of this process compared to conservation, renewable or nuclear energy as substitutes for fossil fuels, and substitution of natural gas for coal.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
AA COAL								
Operating	0.3	0.2	0.3	0.4	0.3	0.3	0.3	0.3
Direct Personnel 1	1	1	1	1	1	1	1	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

PETROLEUM (AC)

Geoscience and Enhanced Oil Recovery (AC-10)

Programs in this area address the economic and technical feasibility of downstream biochemical processing of oils, particularly in terms of complementary treatment to existing refining and upgrading technology. Changes in the chemical physical properties of heavy crudes are brought about by thermophilic microorganisms at elevated temperatures and pressures. The results of recent studies of these phenomena serve as models for the development of new biochemical technologies. These range from (1) upgrading of low grade oils, (2) microbial enhanced oil recovery, (3) biochemical processing of oil waste, and (4) oil spill remediation.

An industry driven, fast turn-around time, technology transfer effort between two national labora-tories and members of the oil & natural gas industry was established in 1988. Since that time, the Natural Gas and Oil Partnership has grown to include nine national laboratories, including BNL. Currently, the partnership is funding the ACTI program in CCD, NSLS, and DAS.

Other BNL projects include field modeling and tracers applications. A study which compares the costs and efficiencies of biochemical vs. chemical upgrading of heavy crude oils is continuing. The application of newly developed biochemical pro-cesses requires an early economic, technical, pilot plant evaluation which will form the basis of continued funding leading to field applications. BNL

also provides analysis support in the oil and gas exploration and production environmental area concerning the incidence and health risks of naturally occurring radioactive material (NORM) in waters associated with oil and gas production.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
AC PETROLEUM								
Operating	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1
Direct Personnel	5	4	4	4	5	5	5	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

INNOVATIVE CLEAN COAL TECHNOLOGY (AZ)

Clean Coal (AZ-02)

Broad environmental analytical support to the DOE Office of Fossil Energy is provided concerning problems arising from air, water, and solid waste pollutants associated with the use of fossil energy in the Clean Coal Technology Program (CCTP). The principal thrust focuses on environmental matters, but analysis of technical, economic, and regulatory issues may also be required.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
AZ INNOVATIVE CLEAN COAL TECHNOLOGY								
Operating	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.2
Direct Personnel	2	1	2	2	1	1	1	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

NUCLEAR SAFETY OVERSIGHT (NS)

Facility Safety Analysis

BNL provides technical and analytical support to the Office of Nuclear and Facility Safety (EH-3), in reviews of Environmental Assessment (EA)/Environmental Impact Statements (EIS), Deactivation, Decontamination, Decommissioning and Dismantlement (DDD&D). BNL also supports the Seismic Qualifications Users Group and provides technical assistance in tasks related to Aging and System Integrity, and development of Analytical Methods. The scope of this program encompasses a wide range of disciplines including systems analyses, risk analyses, reactor physics, thermal hydraulics, waste management, structural

mechanics, electrical systems, fire protection and human factors. This program also supports secretarial nuclear safety initiatives [including support for the Interagency Nuclear Safety Review Panel, Spent Nuclear Fuel and Excess Fissile Material Initiatives].

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
NS NUCLEAR SAFETY OVERSIGHT								
Operating	0.4	0.7	0.2	0.2	0.2	0.2	0.2	0.2
Direct Personnel	2	3	1	1	1	1	1	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

POLICY, PLANNING, AND SYSTEMS STUDIES (PE)

Environmental Analysis (PE-04)

The purpose of this effort is to provide technical assistance in program management and coordination of health and environmental impact assessment programs, continuation of development of assessment tools and information and specific reviews and assessments of energy technologies, environmental systems or policies as requested by the DOE.

BNL is constructing a soft link between MARKAL and Jorgenson-Wilcoxen economic model to examine the technological structure of the U.S. energy system and implications for the U.S. economy of different goals and strategies for CO_2 emission reduction. MARKAL is a technology-rich energy systems model driven by energy demand specifications that produces a least-cost energy system configuration. It does not, however, feed back effects of increased fuel prices on demand, nor does it capture the macroeconomic effects of energy system investments in new technology. The Jorgenson-Wilcoxen model is an intertemporal, general equilibrium model of the U.S. economy. An earlier version of this model was once coupled with BESOM, a predecessor of MARKAL.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001*	2002**
PE POLICY, PLANNING, AND SYSTEMS STUDIES								
Operating	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Direct Personnel	1	1	1	1	1	1	1	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

B. WORK FOR OTHER DOE CONTRACTORS

The Laboratory carries out a number of tasks from a variety of other DOE contractors. The total funding for such programs in FY95 were approximately $18.2M. Increased activity during FY95 was related to the International Nuclear Safety Program (INSP) which is now funded through Pacific Northwest Laboratory. Total funding for FY96 was $17.5M. The details of this program can be found on Page 88.

The Laboratory has a project which provides engineering analysis and technical support in environ-mental pollution problems in Poland, specifically in the city of Krakow. Poland's primary fuel source is bituminous coal, which is mined and burned at the annual rate of 160 million tons for domestic consumption. Very little of the coal is cleaned and air pollution control equipment is not in use. Our project studies pollutants from low source emissions: residential heating systems and boiler houses which supply heat to local districts (one or more city blocks). The results from the Krakow project will provide valuable data to develop an environmentally acceptable model for the efficient use of coal where similar pollutant problems are known to exist.

A laboratory for studying the performance of Polish home coal stoves has been built at the Academy of Mining and Metallurgy in Krakow and an extensive test series has been completed. Because of their high emission factors, these stoves are primary sources of CO and organic soot. A program of boiler testing has been started in cooperation with the staff from Krakow Polytechnic University. Engineering studies have been done to develop costs for selected pollution control strategies, as well as impacts on air quality. Strategies being considered include gas conversion, conversion to electric heating, improved combustion technologies and use of improved coal. Economic analysis and recommendations for incentives the city can use to implement pollution control options will be completed. BNL is working with PETC to develop a follow-on program that will capitalize on the strengths developed in the Krakow Project. Efforts will be targeted to Eastern Europe, with China, India, and states of the former Soviet Union being additional possible partners.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
OTHER DOE LABORATORIES								
Operating	18.2	17.4	9.5	8.7	8.7	8.7	8.7	8.7
Capital Equipment	--	0.1	--	--	--	--	--	--
Total Cost	18.2	17.5	9.5	8.7	8.7	8.7	8.7	8.7
Direct Personnel	40	34	30	30	30	30	30	30

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

C. SUPPORT FROM OTHERS/WORK FOR OTHERS

Programs funded by non-DOE sources continue to be a limited but strong component of the Laboratory's efforts. Studies that broaden and complement DOE supported work are considered Support From Others. They are in support of our research efforts and enhance our ability to fulfill our DOE missions. Studies that take advantage of the special expertise and facilities available at BNL to study other institutions' concerns are our response to other national needs and are considered Work For Others. Because of this fundamental difference the two types of programs are grouped separately.

1. SUPPORT FROM OTHERS

DEPARTMENT OF HEALTH AND HUMAN SERVICES (DHHS)

The Department of Health and Human Services supports a broad range of research efforts in the Biology, Chemistry, Medical, and Applied Science Departments. The programs range from very basic research efforts in genetics, biochemistry and molecular biology to instrument-intensive projects making use of the NSLS, the HFBR, STEM, PET facilities, the Medical Research Reactor and the Brookhaven Linac Isotope producer. In general, support is sought for work that is closely related to the DOE mission and which enables the Laboratory to take advantage of its special expertise and unique facilities. The support from DHHS has helped to reduce the severe cutbacks imposed by the decreasing budgets for DOE-supported biomedical programs. Among the larger efforts funded were studies of low-level radiation effects, studies on DNA repair, mass measurements of single molecules using the Scanning Transmission Electron Microscope, metabolism and neurological research using PET, neutron capture therapy, chemical carcinogenesis, radiotracer R&D in nuclear medicine and neurosciences, and a Clinical Neuroscience Center for Drug Abuse Research. Work is expected to continue in these areas and funding for new efforts which meet the criteria stated above will be sought. The areas which we expect to grow fastest are those asso-ciated with our unique and complex research facilities. Our goal is to continue to expand the avail-ability of these facilities to an ever increasing number of users. The joint funding pattern, where DOE supports the facility construction and BNL staff and NIH (or NSF) supports some of the operating costs of the facility and most of the outside users, is one that we find works to the benefit of all concerned.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
DEPARTMENT OF HEALTH & HUMAN SERVICES								
Operating	4.1	4.3	4.2	3.8	3.8	3.8	3.8	3.8
Direct Personnel	16	16	15	14	14	14	14	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

DEPARTMENT OF DEFENSE (DOD)

For the Office of Naval Research BNL is also exploring the ways in which the acoustic Doppler current profiler (ADCP) can be used to assess zooplankton abundance and its relationship to physical features also measured by the instrument. Samples collected in the Sargasso Sea, Gulf Stream wall, and slope water habitats will be compared with backscattered intensity measured by a ship-mounted ADCP in an effort to calibrate the ship-mounted instrument as a device to measure zooplankton abundance in the sea.

DOD has been supporting our digital subtraction coronary angiography project at the NSLS. This effort is now obtaining unprecedented research-quality images. It is described in more detail in the section on Medical Applications (KP-06) programs.

DOD's Defense Nuclear Agency is evaluating ^{239}Pu (and possibly other nuclides) in various mili-tary and civilian personnel. BNL's fission track analysis method (FTA), presently used as part of a DOE-funded Marshallese dose assessment project, will first be applied to samples to define background levels of ^{239}Pu in veterans not exposed to nuclear weapons or directly to their fallout, or to occupational exposure to plutonium. A parallel effort will upgrade and automate the FTA methodology in anticipa- tion of the need to process large numbers of samples with greater precision and accuracy. The improved system will be used to process additional samples in the future from individuals in the Nuclear Test Personnel (NTP) Review Program.

There has been an increase in the number of programs funded by various branches of the Depart-ment of Defense. Areas in which work is underway include basic studies in the interactions between polymeric materials and metallic surfaces, alumina-based particle optical measurements, advanced water splitting technologies applied to designs of cryogenic fuels plants, and high power metal-hydride fuel additives.

Studies are being conducted to determine the optical constants of alumina-based particulate matter over the frequency ranges from ultraviolet to far infrared and at temperatures up to 2500°C.

Plutonium bioassay of urine using High Performance Liquid Chromatography (HPLC) and Inductively Coupled Plasma/Mass Spectroscopy (ICP/MS) supports the Nuclear Test Personnel Review Program of the Department of Defense/Defense Nuclear Agency.

RESEARCH INITIATIVE

Planar Optic Flat Panel Display

While researchers around the world are laboring to perfect liquid-crystal displays (LCDs), electro luminescent devices, and other technologies that promise to replace the cathode ray tube, Brookhaven has recently patented a new planar optic laser-driven display technology that may provide high resolution imagery in a small package. With further development the technology should lead to a 2-M diagonal planar optic display that supports the high-density TV format of 1000 vertical and 1330 horizontal lines - all in a screen that is only 2 in. thick on the bottom. The technology is also very attractive for aircraft cockpit displays. Unlike current LCDs, a planar optic laser-driven display would not suffer from washout in bright sunlight and other problems inherent in the application of LCDs.

The U.S. Air Force and other agencies have expressed interest in the further development of this technology especially for cockpit display applications and large screen TV displays.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
DEPARTMENT OF DEFENSE								
Operating	14.0	2.9	2.5	2.1	2.1	2.1	2.1	2.1
Capital	--	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Cost	14.0	3.0	2.6	2.2	2.2	2.2	2.2	2.2
Direct Personnel 22	16	12	12	12	12	12	12	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

NATIONAL SCIENCE FOUNDATION (NSF)

The Protein Data Bank (PDB) database of structural information for biopolymers is supported by NSF and NIH, as well as by the DOE Office of Health and Environmental Research. The PDB, an essential resource for research in structural biology, is distributed worldwide to an extensive user community currently estimated to number more than 5,000 scientists.

In oceanographic and atmospheric sciences, there are programs investigating ecosystems not impacted by man's energy-related activities (NSF, ONR); investigating remotely sensed ocean properties (NOAA, NSF); investigating large-scale tracers of ocean/atmosphere interaction (NOAA, NSF); and investigating innovative instrumentation and applications (NASA, ONR, NOAA, EPA).

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
NATIONAL SCIENCE FOUNDATION								
Operating	1.5	1.3	1.6	1.6	1.6	1.6	1.6	1.6
Direct Personnel 5	4	5	5	5	5	5	5	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

OTHER FEDERAL AGENCIES

Programs are supported by several other federal agencies. Typical are EPA health risk assessments of hazardous and mixed-waste disposal sites and National Science Foundation programs in neutron scattering and protein structure determination, and precollege science and mathematics education.

A joint EPA, NRC, DOE Program has been initiated which addresses the technical foundation, application, and coordination of pollutant pathway models used in Remedial Investigation/Feasibility Studies (RI/FS)

programs at sites under the control of these agencies. Other studies include composite material studies, electrically conducting polymers, and the reporting of trauma from motor vehicle accidents, for the Department of Transportation (DOT), and biomass utilization and energy use in rural activities for the Department of Agriculture.

A program is in place from a Federal Interagency team to support MAGLEV activities at BNL. The Federal Interagency team is headed by the Department of Transportation (DOT) through its Federal Railroad Administration under a Memorandum of Understanding (MOU) with DOE.

A program in support of DOT FHWA is nearing completion of its Phase I efforts to develop and test a predictive simulator for traffic management and public information.

RESEARCH INITIATIVE

Booster Applications Facility

A Memorandum of Agreement (MOA) is under preparation to establish formal scientific collaboration between the Life and Biomedical Sciences and Applications Division (LBSAD), within the Office of Life and Microgravity Sciences and Applications (OLMSA) of NASA, and Brookhaven National Laboratory (BNL). The major goals of this collaboration are: (1) to implement the use of unique BNL accelerator facilities, such as the Alternating Gradient Synchrotron (AGS) and the Booster to simulate components of the space radiation environment; (2) support scientific investigations intended to acquire basic knowledge of living systems and their response to radiation exposure in space; and, (3) promote science and technology developments, based on BNL capabilities, that meet NASA requirements for radiation protection in space. These goals are in conformity with the Memorandum of Understanding (MOU) between NASA and the Department of Energy (DOE), signed on July 9, 1992 by NASA Administrator Daniel S. Goldin and Secretary of Energy James D. Watkins. This MOU recognizes that understanding radiation risk is one of the most significant issues in qualifying humans and space hardware for long duration space flight, and stipulates that "....DOE shall conduct research and maintain and operate irradiation facilities, including particle accelerators, necessary to simulate space radiation fields."

The space radiation environment consists of protons and electrons trapped in the Earth's magnetic field, protons (and some heavier particles) emitted in the course of solar disturbances known as solar energetic particle (SEP) events, and protons and the energetic nuclei of other elements (HZE particles) that constitute galactic cosmic rays (GCR). Of particular concern are the radiation effects due to the heavy-ion component of the GCR spectrum. The relative biological effectiveness (RBE) or the quality factors (Q) of energetic heavy-ions are not known, and the validity of these concepts, which are related to the biological effects of x-rays, is in question.

Research on the radiobiological effects of high-energy heavy-ions has been carried out for many years at the Lawrence Berkeley Laboratory Bevalac. With the closing of the Bevalac, BNL is the only accelerator laboratory in the U.S. which can provide heavy-ion beams throughout the full range of the galactic cosmic-ray heavy-ion spectrum.

NASA has commissioned a design study to build a Booster Applications Facility (BAF) at BNL. This facility would deliver a variety of high-Z, high-energy (HZE) particle beams with energies ranging from a maximum of 1.5 GeV/A for the lightest ions, to approximately 1.25 GeV/A for iron and approximately 350 MeV/A for gold. The BAF design study was reviewed by a NASA panel and, subsequently, was the subject of

a DOE Technical Review, which found the proposal technologically feasible and the costs realistic. Funding for construction and operation of the BAF is not currently available, but must be negotiated between NASA and DOE. This proposal in FY93 had a TECC of $32.0 M and a TPC of $35.69 M with appropriations of $5.8 M (FY94), $14.4 M (FY95) and $11.8 M (FY96).

The AGS delivers protons up to approximately 30 GeV and heavy-ions with energies of approximately 10 GeV/A. The minimum energy of AGS beams that can be used by experiments is limited by the residual field of extraction magnets and the residual air in the beam transport system. It is likely that the AGS will be able to deliver ^{56}Fe beams with energies as low as 1 GeV/A. This energy is sufficiently low to offer a suitable benchmark for comparison with radio-biological experiments at 600 MeV/A, performed at the Bevalac. It is also the GCR energy corresponding to the median dose point (i.e., approximately 50% of the GCR dose is delivered by radiation with energies above 1 GeV/A).

The mechanisms of the radiobiological action of charged particles are closely related to their patterns of energy deposition (i.e., the "track structure"). On the one hand, increasing the charge of densely ionizing HZE particles increases the number density of secondary electrons and, hence, the energy deposition at all distances from the particle track. At a high enough energy deposition the density of chemical byproducts of ionization is sufficiently large for re-combination to prevail and radiation effects tend to saturate. On the other hand, increasing the energy of HZE particles at constant charge, results in more energetic secondary electrons and, therefore, a lesser ionization density. The study of the dependence of biological effects, such as the size of deletetions in DNA as a function of track structure, is essential for the development of microscopic models of radiation action. Of comparable importance is the fact that the probability for nuclear reactions, or cross section, changes with particle energy. The kind of particles emitted from every nuclear interaction, their number, and their energy distributions will all be different. The current knowledge of heavy-ion physics is not adequate to predict the details of these interactions, either for the incident high-energy particles or for the multitude of interaction products. As a consequence, the radiation field behind shielding materials or inside the tissues of a human body will differ substantially from that produced by lower energy particles. Thus, studies with AGS beams are an essential complement of eventual studies at BAF energies and would need to be pursued even if the BAF were available.

In order to begin the research covered by this MOA, a proposal entitled "Genetic and Epigenetic Effects Produced By High-Energy Heavy-Ions," was submitted at the invitation of AGS management for review. The proposal has been reviewed for scientific merit and approved for running at the AGS. This proposal requests 240 hours of beam time in FY95 using 1 GeV/A ^{56}Fe particles, of which 40 hours would be for beam development and testing. The proposal groups scientists supported by NASA at the Lawrence Berkeley Laboratory, the Jet Propulsion Labora-tory, the University of California at Davis, the University of San Francisco, Colorado State University and Columbia University. The proposed experiments have been selected to place the minimum possible demands on the AGS and yet result in scientifically significant data. Success-ful performance of these experiments will clear the way for regularly scheduled periods of AGS running, dedicated to space radiobiology, in which BNL scientists would participate under the terms of the MOA. The first 120 hours of beam were successfully delivered in October 1995. The second 120 hours are scheduled for September 1996. Negotiations are underway to support this program through FY98.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**

OTHER FEDERAL AGENCIES

Operating	2.9	0.8	1.8	1.9	1.9	1.9	1.9	1.9
Capital Equipment	0.4	0.1	--	--	--	--	--	--
Total Cost	3.3	0.9	1.8	1.9	1.9	1.9	1.9	1.9
Direct Personnel	15	11	7	7	7	7	7	7

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

ALL OTHERS

Support for several substantial programs is in place or is being developed by private non-profit organizations. Major units are the Electric Power Research Institute (EPRI), supporting programs in studies of atmospheric pollution mechanisms, fuel conversion, efficient energy utilization, coal-water slurries, new homogeneous methanol catalysts, and catalysis studies on coal-derived asphaltene hydro-genation and carbonylation and underground oil leak detection using PFTs; the Gas Research Institute (GRI), supporting programs in fuel cells, materials combustion, corrosion, catalysis, and analysis of plant operations; and the Empire State Electrical Energy Research Corporation (ESEERCO), pro-viding assistance in the area of nuclear waste regulation. ESEERCO is also sup porting efforts in the testing of the improved forms of insulation developed in the AK-06 program. In addition, programs are being developed with several private corporations in which they will support work on various areas of catalysis, coal cleaning, combustion, waste disposal, and acid rain research, experiments at the NSLS, and tracing leaks in underground cable. ESEERCO is also supporting development of an energy systems model of New York State to explore greenhouse gas emissions reduction strategies and their interaction with emissions of other pollutants. ESEERCO is funding a program in support of high speed interactive computer simulations for PWR power plants.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
ALL OTHERS								
Operating	3.1	2.1	4.5	5.0	5.0	5.0	5.0	5.0
Direct Personnel 15	34	46	51	29	24	24	24	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

2. WORK FOR OTHERS

NUCLEAR REGULATORY COMMISSION (NRC)

Brookhaven National Laboratory conducts programs concerned with nuclear energy in the areas of advanced reactor systems, safety of fission reactors, nuclear waste management, and nuclear materials safeguards. Programs sponsored by the Office of Nuclear Reactor Regulation and the Office of Nuclear Regulatory Research are major efforts. Programs in the areas of risk assessment, human performance, accident analysis, seismic and structural evaluation, harsh environment material tests and engineering analysis are important major efforts at the Laboratory.

Office of Information Resources Management (10-20)

BNL provides computer support to the NRC staff through funds from the Office of Information Resources Management, as well as providing technical assistance in the area of data computerization to the NRC in its issuance of annual reports on nuclear power plant effluents.

Office of Nuclear Reactor Regulation (20-19)

BNL has programs that provide technical support in the following areas:

1. Materials Characterization and Evaluation

   Operating reactors: maintenance issues, erosion/corrosion programs, component failures analyses;
   Experimental studies of polymer response to harsh environments;
   New reactors: licensing review of Westinghouse AP600, GE SBWR and CESSAR 80+ reactor design Safety Analysis Reports for compliance with NRC Standard Review Plan requirements, specifically related to materials and chemical engineering issues; review of control room human factors.

2. Engineering Research and Applications

   Technical assistance in support of advanced reactor designs, including the development of piping benchmark problems and the evaluation of modular construction techniques;
   Development of guidelines for resolution of the USI A-46 regarding seismic evaluation of equipment in operating plants;
   Study of aging mechanisms for the operating reactors and development of a standard review plan for assessing the aging degradation of systems, structures and components for license renewal;
   Evaluation of new methods of analysis proposed by licensees for new or modified systems;

Evaluation of civil, structural and mechanical engineering issues for operating reactors;
Inspection and auditing of plants for implementation of NRC ratings and resolution of generic issues;
Evaluation of the ultimate capacity of a degraded containment to assess the sensitivity to the severe accident risk profile.

3. NRC Codes and Standards

BNL currently provides technical support to the NRC for code and standard activities. In the Inservice Testing (IST) program, BNL provides support to NRC/NRR in reviewing IST program submittals from the nuclear utilities to ensure they have met the requirements of the ASME Code with regard to inservice testing of safety-related components. BNL also provides technical support in conducting site audits of plant IST programs. In another program, BNL acts as a technical liaison for the NRC with the ASME Code committees.

4. Probabilistic Risk Assessment Implementation

With more attention at the national level to the development and application of probabilistic methods to evaluate the impact of technology or societal risk, BNL has developed a PRA implementation initiative. This work, funded through NRC, Office of Nuclear Reactor Regulation, includes methods development and validation, as well as regulatory applications. Through these programs, BNL will be supporting the many decisions that will be made over the next three years as the regulation of reactor safety moves away from the prescriptive deterministic process currently in place to that of a more risk and performance basis. This will include:

a) development of decision criteria,
b) pilot application to specific regulatory issues and methods for development,
c) inspections,
d) operator licensing,
e) event assessment,
f) generic issues,
g) regulatory effectiveness,
h) advance reactors, and
i) accident management.

Staff will be evaluating the needs of each regulatory application as compared to current strengths and weaknesses of available probabilistic tools and as necessary, modify them or develop new tools as needed.

Office of Nuclear Material Safety and Safeguards (50-19)

BNL provides technical assistance and confirmatory research in the area of radioactive waste management.

BNL staff have worked for the NRC to develop the DUST (Disposal Unit Source Term) computer code that evaluates the rate of contaminant release (i.e., the source term) from low-level waste dis-posal facilities. The DUST code has been applied to evaluating releases from a hypothetical Class A and Class B/C disposal vaults for the NRC. Training of NRC staff and representatives from State Compacts has been provided.

The Materials Characterization and Evaluation Group (MCE) provides technical support to NMSS for low-level radioactive waste management. The most recent task reviewed compliance of West Valley (NY) waste solidification programs with NRC requirements affecting the long-term waste stability of processed wastes.

Technical safety issues related to the design, operation, and maintenance of nuclear power plants (NPPs) arise periodically as a result of operational events or the NRC's continuing program of inspection and assessment. BNL has applied its engineering skills to assisting the NRC in resolving these issues. Evaluations have been completed

covering a myriad of topics both at the equipment and system level in order to assist NRC in developing technical resolutions to the issues.

Office of Nuclear Regulatory Research (60-19)

Programs include 1) studies of problems related to solidification, leaching, and source term evaluation of wastes in low level waste disposal sites; 2) assessment of codes for light-water reactors and advanced reactors; 3) construction and subsequent operation of a high-temperature combustion facility; 4) reactor safety experiments; 5) the use of risk and reliability techniques in evaluating reactor technical specifications and safety systems; 6) seismic and structural analysis including soil/structure interaction, component fragility, containment loading and performance; 7) environmental survivability and qualification of safety-related nuclear equipment; 8) probabilistic risk assessment, severe accident analysis, and individual plant examinations (IPE); 9) development of in-plant training programs for health physics technicians; 10) materials corrosion studies, and improvements in engineering method-ology, e.g. protective action decision making, generic issues and transient analysis, as applied to nuclear power plants; 11) analysis of aging mechanisms and reliability of plant components; 12) source term analysis and verification; 13) advanced reactor concepts; 14) accident management; 15) technical assistance and quality assurance in radiation protection related to consumer products and medical use of byproduct material; 16) studies on the impact of reduced dose limits, effects of "hot particles" on skin, ALARA engineering at nuclear power plants, and licensing issues related to the use of radiolabeled monoclonal antibodies; 17) use and application of concepts related to risk-based regulation; and 18) digital instrumentation and control systems designs.

Some of the assignments for which BNL is uniquely qualified include:

1. Engineering Research and Applications

BNL is: developing criteria for seismic qualification of equipment in advanced light-water reactor plants which will drastically reduce the cost of equipment qualification while retaining confidence in its functionality; performing cooperative test programs with Japan and exchanging technical information with them on seismic issues; assessing structural integrity of modular construction for advanced reactor designs; and participating in the seismic shear wall international standard problem.

2. Chemical Detonation Physics

To assess the possible threat to containment and safety-related equipment of nuclear reactor plants under severe accident conditions, it is necessary to understand how hydrogen is transported and mixed within containment, and how to determine the likelihood of various modes of hydrogen combustion. Since 1979, much research addressing hydrogen behavior issues has been conducted. Several impor-tant areas of uncertainty remain, viz (I) high-temperature/high-steam concentration combustion and (ii) deflagration-to-detonation transition. These issues are not only related to existing LWRs but might have to be addressed in assessing evolutionary and revolutionary nuclear reactor designs.

BNL is nearing completion of a research program dealing with the experimental simulation and analytical modeling of the gas dynamic and chemical reaction phenomena associated with the com-bustion of hydrogen, air, and steam mixtures at initially high-temperature and high-steam concentrations. This research project is jointly funded by the U.S. Nuclear Regulatory Commission and the Japanese NUPEC organization. The objective of the research program is to provide an understanding of hydrogen-steam-air gas mixture detonation phenomena for mixture temperatures up to 800 F.

3. Environment and Waste Technology

Development of models to evaluate the rate of contaminant release (i.e. the source term) from low-level waste disposal facilities. Codes have been developed to address different release scenarios. All of the codes simulate fluid flow, container performance, waste form performance, and near field transport.

4. Engineering Technology

Both commercial nuclear reactors and DOE nuclear facilities have begun to reach notable ages and require a systematic assessment of the effects of age-related degradation on structures, systems, and components to assure continued safe and reliable operation.

The BNL Research Program on Aging Systems is focused on technical safety issues related to degradation of electrical and mechanical components, safety systems, support systems, and civil structures in commercial nuclear power plants. Research is underway to identify and characterize the aging mechanisms of material and component degradation, and to evaluate current methods of inspection, surveillance, condition monitoring and maintenance.

A broad-based environmental qualification research program is being conducted on cables using naturally aged cables from nuclear power plants. Accident conditions are simulated to evaluate the ability of the cables to survive. Degradation of the naturally aged cables is compared against new cables which are artificially aged through accepted accelerated aging techniques.

Studies are continuing in the area of DOE/Industry research, including the development of a data base on research and plant practices and processes related to dose control.

A related project on "Interpretation of Bioassay Measurements" will provide a comprehensive manual describing how to compute intakes of radioactive material from both in vivo and in vitro bioassay measurements.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
NUCLEAR REGULATORY COMMISSION								
NUCLEAR REACTOR REGULATION(a)								
Operating	2.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0
Direct Personnel	16	7	8	8	8	8	8	8
NUCLEAR MATERIAL SAFETY & SAFEGUARDS								
Operating	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Direct Personnel	1	1	1	1	1	1	1	1
NUCLEAR REGULATORY RESEARCH								
Operating	12.2	8.5	7.5	7.5	7.5	7.5	7.5	7.5
Capital	0.1	--	0.1	0.1	0.1	0.1	0.1	0.1
Total Cost	12.3	8.5	7.6	7.6	7.6	7.6	7.6	7.6
Direct Personnel	56	47	44	43	43	43	43	43
TOTALS-NUCLEAR REGULATORY COMMISSION								
Operating	15.1	9.5	8.6	8.6	8.6	8.6	8.6	8.6
Capital	0.1	--	0.1	0.1	0.1	0.1	0.1	0.1
Total Cost	15.2	9.5	8.7	8.7	8.7	8.7	8.7	8.7
Direct Personnel	73	55	53	52	52	52	52	52

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars
(a) Office of Administration and Resource Management work reflected in Nuclear Reactor Regulation

DEPARTMENT OF STATE (DOS)

International Safeguards Project Office

The International Safeguards Project Office (ISPO) provides administrative and technical support to the U.S. interagency Subgroup on Safeguards Technical Support (SSTS). The SSTS, operates under and reports to the Subcommittee on Safeguards and Monitoring, which provides U.S. policy guidance, to implement technical aspects of U.S. support to IAEA safeguards and other monitoring (USSP). The USSP is a coordination of safeguards efforts pursued by various U.S. Agencies, including DOE, to strengthen international safeguards through improvements in the effectiveness and efficiency of IAEA safeguards implementation. The scope of USSP includes:

development, provision, and demonstration of technology (instruments and techniques) for safeguards applications;
support for commercialization, procurement, and implementation of thatechnology;

training of safeguards personnel;
analysis of safeguards issues;
infrastructure support to the IAEA Department of Safeguards, such as providing experts and consultants to work directly with the Secretariat;
recruit and designate U.S. attendees at international safeguards meetings (advisory/consultant).

Since its inception in 1977, ISPO has aided in supplying over $100,000,000 of effort to the IAEA in response to requests made by the IAEA.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**
DEPARTMENT OF STATE								
Operating	3.9	6.7	8.4	8.4	8.4	8.4	8.4	8.4
Direct Personnel 8	14	16	16	16	16	16	16	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

ENVIRONMENTAL PROTECTION AGENCY (EPA)

The Environmental & Waste Technology Center is also working for the EPA on several international activities including treatment of contaminated ash resulting from the Chernobyl accident, eval-uation of Russian waste treatment and disposal practices, characterization of sediments in the Kara and Bering Seas, and conversion of waste sulfur generated by the production of oil in Kazakhstan into environmentally sound and useful products. Waste management practices of the former Soviet Union resulted in the disposal of reactor compartments and spent/damaged nuclear fuel in the Kara Sea. Most of the material was disposed of in a multi-barrier package consisting of a combination of mild/stainless steel, special steel alloys and "Furfurol" polymer. The performance of these packages in the Arctic marine environment depends on the integrity of these barrier materials. In a joint research project with the Kurchatov Institute in Moscow, Russia, BNL is conducting evaluations to gain a better understanding of the performance of the waste packages in the Kara Sea. The performance of the steel barrier is a function of the type of steel used and the container construction tech-niques (e.g. welding). Determination of the corrosion processes of mild/stainless steels is being accomplished through consultation with the Kurchatov Institute in Moscow. The performance of the furfural based barrier is not as straight forward. The final properties, and hence, performance of the polymer can be effected by physical (e.g. filler material) and chemical (e.g. impurities, furan content, co-polymers) formulations, temperature of the resins and receiving waste, quality standards, thermal conditions (e.g. rate of cooling), and catalyst type/amount/combinations.

Finally, the Geochemistry of Contaminants in the Arctic Seas are being studied to determine sorption coefficients (Kd) for radionuclide contaminants (Am, U, Sc, Sr, I, Tc, Co) on a variety of sediments from the Kara Sea and vicinity. Core samples will be screened for anthropogenic gamma-emitters. The effect of liquid to solid ratio on Kd will be examined. The effects of chemical alteration of the sediment through resuspension and subsequent oxidation of reduced minerals will be examined with regard to retention of sorbed radionuclides. Other work to be performed by subcontractors includes development of the Arctic Radiation Information Survey and including this information in a geographical information system (GIS). In addition BNL is assisting the EPA

in conducting negotiations and information exchanges and site inspections related to the "Murmansk Initiative" signed at the Clinton/Yeltsin summit, to reduce radioactive contamination of the Arctic Sea.

RESEARCH INITIATIVE

BREP: Brookhaven-Rensselaer Environmental Partnership

BREP is an environmental partnership formed in 1993 to address aspects of environmental problems, broadly defined, including work on basic research, education, and applications. Specific items are discussed briefly below:

1. Urban renewal in Brooklyn, NY. BREP is working actively on projects that involve cleanup of the Gowanus Canal and a neighboring "brown fields site". Successful completion of the projects will be an important step in improving the local economy and creating new economic opportunities in an economically deprived neighborhood. An environmental education project that will link levels from kindergarten to Ph.D. has been initiated in collaboration with a community development group, public schools, community, four year, and graduate colleges and universities. Linkages have been established with City, State, and federal agencies that have responsibilities for these areas.

2. Sediment decontamination technology demonstration for the Port of New York/New JerseyAt the present time dredged material may not, in some cases, be suitable for either ocean or upland disposal. Buildup of sediments in navigable channels in the port is becoming a threat to the continued operation of shipping in the port. BREP continues to participate in the development of technologies to render these sediments non-hazardous either by destroying or immobilizing the hazardous components. Currently, proposals for pilot scale operations involving different technologies are under review as the next step in developing a treatment system for the sediments. Funding for the BREP work on the project is from the New York District US Army Corps of Engineers and the EPA.

3. Urban lead exposure. BREP is concerned with health effects caused by occupational and environmental exposure to lead. Measurements of bone-lead concentrations are in progress at the New Jersey Medical School in Newark. The intent is to widen the scope of the activities to include a more general study of lead exposures in the city region and to participate in development of better abatement methods.

4. Community College Environmental Education. BREP is actively participating in the organization of the North East Partnership for Environmental Technology Education (NEPETE). NEPETE is part of a national organization formed by DOE, EPA, DOD, and NASA. The intent is to stimulate environmental education at the community college and to increase the number of environmental technicians to provide for the increased labor needed in environmental cleanups at federal and private sites. The NEPETE is very relevant to the BREP programs in Brooklyn and Newark.

PROGRAM SUMMARY
($ in Millions in Budget Authority)
(Personnel in FTE)
(Fiscal Years)

	1995	1996	1997*	1998*	1999**	2000**	2001**	2002**

ENVIRONMENTAL PROTECTION AGENCY

Operating	3.2	1.2	1.2	0.5	0.5	0.5	0.5	0.5
Direct Personnel 7	5	5	1	1	1	1	1	

* Escalation Factors: FY1997 and 1998 operating costs at 3.8% and 4.1% respectively.
** Constant FY1998 dollars

DEPARTMENT OF TRANSPORTATION

BNL proposes to establish a multidisciplinary Evaluation Center for DOE/Intelligent Transportation System (ITS) to provide a "test bed" for the evaluation of ITS technologies from the R&D to the operational testing phase using an integrated systems approach. The Center will be a resource for the metropolitan region, New York State, and the Federal government for programs measuring ITS effectiveness relevant to congestion, safety, energy, and the environment.

Intelligent Transportation System (ITS)

Brookhaven National Laboratory (BNL) and Polytechnic University through a cooperative agree-ment with the U.S. Department of Transportation and the New York State DOT have established a project to determine the efficacy of current and future ITS advanced technologies. This project provides a unique and comprehensive resource which will assist both the Federal and State DOT/ITS agencies in developing mission critical oversight and measures of effectiveness criteria, plans, pro-cedures, demonstrations and operational testing of existing, new and future ITS technologies and systems. The initial set of projects and tasks is intended to directly support the INFORM/Southern State Parkway corridor development program in order to develop and demonstrate at BNL a first-order simulation model of traffic congestion along the INFORM corridor.

ALL OTHERS

Many users from government labs and from industry are using heavy ion beams from the Tandem Van de Graaff to irradiate small semiconductor components to determine their failure rate. These tests are called single event upsets and are used to simulate the effects of, for example, cosmic rays. Also now used as production facility for micropore filters by COSTAR.

RESEARCH INITIATIVE

Infrastructure Modernization

Physical infrastructure in the United States - roads, bridges, water mains, sewers, public buildings, dams, tunnels, airports, etc. - continues to deteriorate. Government studies estimate that over the next 20 years at least 3 trillion dollars - 150 billion annually - is needed just to stop further deterioration and fix the worst deficiencies. Many additional billions are needed if the U.S. is to improve its infrastructure and meet the challenges of the 21st Century. Political and budget realities make such expenditures very unlikely. Nevertheless, the public will demand that government fix the problems. The only solution is to quickly develop and apply new and better infrastructure technologies that do much more with the limited dollars available; that is, build new infrastructure at lower cost and have it last much longer and, in addition, extend the operating life of existing structures and reduce the cost of maintaining and repairing them.

Brookhaven, in association with Northrup-Grumman and Ebasco, and several other academic institutions and industrial organizations in the New York region, have been mobilized into a consortium to meet the challenge of modernizing infrastructure technology and bringing it into the 21st Century. Brookhaven and other consortium members have devised a range of breakthrough infrastructure technologies that will have profound impact on present and future infra-structure. These include devices and methods for greatly increasing the speed for highway and bridge repairs, as well as sophisticated devices for surveillance mapping and in-situ repair of weak points in underground gas pipes, water mains, sewer pipes, etc.

The BNL-led consortium is proposing to establish a National Infrastructure Center for Engineering Systems and Technologies (*NICEST*) located at BNL that will develop, as well as test, 21st Century technologies, compile comprehensive infrastructure data bases, and enable an industry/government/ academic partnership to rapidly improve U.S. infrastructure. The Clinton administration views upgrading of the Nation's infrastructure as a top priority. The *NICEST* Initiative addresses this pressing need directly and, in addition, addresses other important administration priorities as well, including: faster technology transfer from National Laboratories to the civilian sector, conversion of the space and defense industry to civilian use, nurturing of small business development, and enhancement of University R&D to motivate students to pursue technical careers.

D. LABORATORY DIRECTED R&D (LDRD)

The general goals and objectives of BNL's Laboratory Directed R&D Program (LDRD) are to 1) encourage and support the development of new ideas and technology; 2) promote the early exploration and exploitation of creative and innovative concepts; and 3) develop new "fundable" R&D projects and programs. The emphasis is clearly articulated by BNL to be on supporting exploratory research "which could lead to new programs, projects, and directions" for the Laboratory. BNL's LDRD Program generally falls into six broad technical and scientific categories. These are: New Directions for Energy Technologies, Environmental Science and Technology, Radiation Therapies and Imaging, Genetic Studies, New Directions for the Development and Utilization of BNL Facilities, and Other Miscellaneous.

The responsibility of BNL's LDRD Program resides with the Laboratory's Director. The coordination, oversight, and administration of the Program is coordinated by the Laboratory's Deputy Director, who chairs the LDRD Committee. This Committee is comprised of the Associate Directors with programmatic responsibilities,

the Associate Director for Administration, and the Assistant Director for Planning and Policy and is charged with making recommendations on all proposals. The Associate Director for Administration provides assistance on matters relating to Program budget, project accounting, summary reports and reporting Program activities to the DOE.

The BNL LDRD Program does not have any formalized substructure in that any prior, separate or distinct categories of projects are not defined. All projects and their proposals, large and small, regardless of institutional purpose or potential impact, are treated similarly. The availability of special funds for research under the LDRD Program is well publicized throughout the Laboratory. Guidelines issued with the general announcement each year specify the requirements necessary for partici-pation in the Program. Included are the Program's purpose, general characteristics, procedures for applying and restrictions. An application for funding takes the form of a completed Proposal Questionnaire, together with a description of the scientific or technical aspects of the Program. This must be approved by the Department Chairman and cognizant Associate Director. The applications are then forwarded to the Chairperson of the LDRD Committee, who transmits a copy of all proposals received to the LDRD Committee for review and consideration for funding.

The overall Program has worked extremely well. Aside from leading to new fundable or promising programs at the Laboratory and producing especially noteworthy research, it has resulted in numerous publications in various professional and scientific journals, presentations at meetings and forums, patent applications and patents, as well as the support of a number of Post-Doctoral students. The Program is also much appreciated by the scientific and engineering staff, as evidenced by the large number of applications received. It enables BNL scientists to obtain support for programs in a relatively short time for the testing of new ideas.

BROOKHAVEN NATIONAL LABORATORY
DIRECTED R&D FUNDING

($ in Millions - BA)	1995	1996	1997	1998
	2.48	3.5*	4.5*	4.5*

*Estimated

FY96-98 funding level may be constrained due to the overall financial health of the Laboratory, which continue to force BNL to make difficult tradeoff decisions involving programs such as LDRD.

E. SCIENCE AND TECHNOLOGY PARTNERSHIPS

1. REPORT ON ORTA ACTIVITIES

SUMMARY OF TECHNOLOGY TRANSFER PLAN

A. Overview

The Office of Technology Transfer (OTT) manages an active technology transfer program and is the focal point for Brookhaven's ongoing technology transfer activities. The goals of OTT are to create a technology transfer process which: 1) permits the early identification of emerging Brookhaven developed products or processes that may be of commercial interest; 2) permits the identification of unique Brookhaven technical capabilities and facilities that may be of interest to industry, universities and state and local governments; 3) provides an outreach function to bring these new technologies and unique capabilities and facilities to the attention of private industry, universities, and state and local government; and 4) establishes the research collaborations that permit Brookhaven to be a resource to the university community and industry. The Laboratory has two primary goals for its technology transfer program. First, the technology transfer projects conducted by the Laboratory should be complementary to Brookhaven's mission research and should enhance the Laboratory's capabilities to perform research on behalf of DOE. Second, the technology transfer program should make it possible that Brookhaven developed technologies and technical capabilities become resources that permit U.S. industry to enhance its competitive position in domestic and international markets. A number of technology transfer mechanisms are available for Laboratory interaction with U.S. industry and academia; including industry use of Brookhaven's world class designated user facilities, sponsored research, cost-shared research projects under Cooperative Research and Development Agreements (CRADAs), intellectual property licensing, and personnel exchanges.

B. Plan Highlights

Outreach

In order to conduct its technology transfer program, OTT places emphasis on efforts to advise industry, universities, and state and local governments of the Laboratory's capabilities and of the various opportunities to interact with Brookhaven. This is accomplished through an energetic outreach program that involves:

i) Exhibits - A "Technology Opportunities at Brookhaven National Laboratory" theme exhibit has been created with the flexibility to change the photos and captions to match each planned exhibit and/or conference. In FY96, this exhibit will be the focal point for participation by OTT in major exhibits such as the NASA Technology Transfer Conference & Exposition, the Society of Automotive Engineers (SAE) Exposition, and the Federal Laboratory Consortium (FLC) Annual Conference.

ii) Conferences - Conferences and symposia are an excellent vehicle to exchange ideas and information on technical topics of current interest to industry and academia and to enable Brookhaven to target industries where there is a match between Brookhaven technical capabilities and industry's technical and product needs.

iii) Community Interaction - During FY96, OTT will meet regularly with the NY State Small Business Development Centers located at Stony Brook University and SUNY Farmingdale to offer BNL's assistance to new companies and existing companies wishing to re-direct their products from defense to dual use. Presentations will be given to local economic development groups in the different townships on

Long Island. OTT will continue to interact at the monthly Long Island Forum for Technology (LIFT) meetings and will hold periodic meetings with the New York City Partnership; and the NASA funded Research and Development Resource Center at Hofstra University to plan a series of New York City/Long Island based technology transfer workshops/conferences for 1996.

iv) Publications - OTT has published several "outreach" brochures and uses these to communicate detailed information concerning Brookhaven's technology base to U.S. industry. The "Technology Transfer at Brookhaven National Laboratory - Licensing Opportunities" brochure originally published by OTT for Associated Universities, Inc. in June 1991 has been updated and is now available on-line through the OTT Home Page on the worldwide web. The "Office of Technology Transfer" brochure provides an overview of the Laboratory's technology trans-fer options and is a useful introductory tool with industry. The "Applied Programs at Brookhaven National Laboratory" brochure discusses the various applied programs carried out under the direction of the Departments of Advanced Technology and Applied Science. This brochure was published by OTT in 1991 and has been widely distributed to industrial concerns interested in Brookhaven's applied capabilities and in undertaking collaborative research projects with the Laboratory. The "Biotechnology at Brookhaven National Laboratory" brochure was issued in Spring 1996 to reach the industrial biotechnology community. Two new brochures are in the advanced planning stages; the first will cover Brookhaven's designated user facilities, highlighting capabilities of particular interest to industry, and the second will be an update of the Applied Programs brochure.

v) Technical Assistance - OTT responds to several requests a week for technical information. These either come directly to the Laboratory or are referred by other laboratories, the FLC network, or the National Technology Transfer Center (NTTC). OTT handles each request differently. If the inquiry involves a field where there is technical expertise at the Laboratory, OTT tries to direct the client to a Brookhaven researcher; if the requested expertise is not resident at Brookhaven, OTT directs the inquiry to another laboratory; and if OTT does not have enough information to make either referral, it will direct the client to the FLC Clearing House. OTT continues to participate with the FLC and NTTC so that Brookhaven facilities and capabilities are included in the various data bases being assembled by these two organizations.

vi) Federal Laboratory Consortium (FLC) - OTT provides a staff member as the Laboratory representative to the FLC. The Brookhaven representative to the FLC is also the Deputy Coordinator for the Northeast region of the Consortium and is responsible for coordination of special requests from industry to the Northeast laboratories. Brookhaven's FLC representative makes numerous presentations to Northeast regional businesses about Brookhaven's technologies available for commercialization and about how Brookhaven and the FLC work closely together to provide requestors with technical help.

Internal Laboratory Technology Transfer Training

OTT recognizes that Laboratory culture has a significant impact on technology transfer. Thus it conducts ongoing programs to: 1) address all new supervisors either hired or promoted during the year at a Personnel seminar; 2) insure that Brookhaven researchers accompany OTT staff to exhibitions to relate their expertise to industrial audiences; 3) conduct departmental seminars to educate the researchers regarding the Laboratory's technology transfer program and the technology transfer options available, including intellectual property protection and licensing; 4) meet at least twice yearly with the Brookhaven Technology Transfer Coordinating Committee, composed of representatives from each Research Department and Division, to advise them in depth of the Laboratory's opportunities to collaborate with industry; and 5) publishes each month on the Brookhaven Technology Transfer Homepage its "Research News" which advises the Laboratory research staff of new funding opportunities in the public and private sector and new DOE/industry partnerships.

Work for Non Federal Sponsors

The Laboratory's work for non-federal sponsors program, under which Brookhaven performs research for industry, universities, non-profit sponsors, and state and local government, is of great significance for technology transfer. Of particular importance, through this mechanism unique Laboratory facilities and capabilities can be made available to industry to address specific private sector technical needs. During the past several years, Brookhaven has conducted proprietary research for several individual northeast utilities as well as for the non-profit research institutions representing the utility industry. Recently the pharmaceutical industry has shown interest in funding research using the capabilities of the Laboratory's PETT research program and several drug firms have already funded studies at Brookhaven.

Brookhaven's Five Year Technology Transfer Plan

Brookhaven's five year plan is directed to continuing and strengthening the activities described above. Brookhaven is serving as the pilot laboratory for the Energy Research Laboratory Technology Transfer Program to establish an integrated technology transfer office at each ER multi-program laboratory. The implementation plan to establish this office was submitted to ER in the Spring of 1995. Brookhaven's OTT is the focal point for all the Laboratory's technology transfer/technology utilization/cooperative research interactions with U.S. industry, academia, non-profit institutions and state and local government.

The Technology Transfer Coordinating Committee serves to link OTT to the research departments and divisions. The scientists who make up the Committee are a close link to the principal investigators and bench scientists in their departments. They keep OTT informed of R&D activities that have potential for commercialization and they keep the researchers informed of technology transfer oppor-tunities. Increased interaction between OTT and the Coordinating Committee is planned. This will be coupled with OTT's continuing efforts to develop means to improve communications and education efforts with the research staff concerning technology transfer opportunities.

AUI's active licensing program for managing inventions, identifying industrial licensees, and steering them toward commercialization of Brookhaven technologies will continue to grow. Significant effort will be devoted to advising targeted industry of the opportunities to conduct cost-shared research at the Laboratory. These efforts, combined with continued DOE CRADA funds, should result in the Laboratory's CRADA activities remaining valuable research collaborations with industry. Significantly expanding the Work for Non-Federal Sponsors program is an important aspect of Brookhaven's five year technology transfer plan.

ORTA ACTIVITY

($ In Thousands)	1995	1996	1997	1998	1999	2000	2001	2002
Funding								
ORTA Activity[b]	650	473	500	500	500	500	500	500
Patent/Licensing Activity[c] 214	150	150	150	150	150	150	150	
TOTAL	864	623	650	650	650	650	650	650
Staffing (FTE)								
ORTA Activity	6	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Patent/Licensing Activity 4	3.5	3.5	3.5	3.5	3.5	3.5	3.5	
TOTAL	10	8	8	8	8	8	8	8

[a] All figures for FY97-02 are estimated.

[b] ORTA Activity covers outreach, user facilities, ER/LTR program, work-for-non-federal partners.

[c] "Patent/Licensing Activity" covers manuscript review, invention identification, patentability searches, invention reporting to DOE, intellectual property support for procurement.

2. INDUSTRY-LABORATORY COOPERATIVE PROJECTS

Cooperative Research and Development Agreements (CRADAs)

Brookhaven's cooperative research program experienced significant growth between FY92 and FY95, but was significantly reduced in FY96. During FY92, Brookhaven entered into four cooperative research and development agreements (CRADAs) with private industry, three of them with small companies. In FY93, the Laboratory entered into thirteen more CRADAs, ten with small companies. In FY94, Brookhaven entered into eighteen new CRADAs, with ten of these cooperative research programs involving small businesses. In FY95, the Laboratory entered into thirty-two new CRADAs, with sixteen of these projects involving small businesses. In FY96, it is anticipated that only one new small one year CRADA will be put in place, with most of the DOE funding in FY96 being used to continue support of Brookhaven's on-going multi-year CRADAs commenced in FY94 or FY95. The CRADA program's growth can be measured in terms of the DOE funding support to Brookhaven for CRADAs: FY92 - $835K; FY93 - $630K; FY94 - $3,813K; FY95 - $9,395K; FY96 - $2,468K.

As Brookhaven's CRADA program has grown, the Laboratory has established a cooperative research portfolio that utilizes the various technology areas in which Brookhaven has significant research capabilities and expertise. CRADA programs have been initiated in the technology areas of advanced materials, advanced computing and modeling, bioscience and biotechnology, nuclear medicine, environmental monitoring and remediation, and optical instruments. A number of the Laboratory's research departments are participating in CRADAs, including Biology, Medical, Advanced Technologies, Applied Science, Physics, Chemistry, NSLS, Instrumentation, and Computing and Communications. Several of the Brookhaven CRADAs support the Laboratory's participation in two major DOE/Industry Partnership Initiatives, the AMTEX project and the ACTI project.

Brookhaven entered into twelve multi-year CRADAs in FY94 and thirteen in FY95. OTT coordinates the process by which the Laboratory performs an annual review of ongoing multi-year CRADA projects as assurance that each project continues to meet the high research standards of the Laboratory and continues to have commercial relevance. OTT's program management responsibility also includes an evaluation of each cooperative research program upon completion. This evaluation applies a series of metrics in an effort to assess the success of each cooperative research program in terms of meeting its technical objectives and also in satisfying the commercial objectives of the industry partner.

Personnel Exchanges, Technology Maturation and Technical Assistance

DOE continues to provide funding support for Brookhaven to utilize three other components of its technology transfer program, personnel exchanges, technology maturation projects, and technical assistance projects.

Personnel exchanges with industry and universities have served as introductory collaborations that have led to a mutual interest in pursuing larger CRADA research programs or sponsored research projects. During FY94, Brookhaven initiated three personnel exchange projects in three different technical areas of importance to the Laboratory, accelerator development, radiolabeled monoclonal antibodies and detector materials. In FY95, Brookhaven also initiated three personnel exchanges, again in technical areas of significance to the Laboratory, materials characterization and nuclear medicine imaging. In FY96 it is anticipated that the Laboratory will initiate one new personnel exchange.

The Laboratory will continue its use of technology maturation projects as a strategy for developing commercially promising technologies and ultimately transferring the technologies to industry. In FY94 Brookhaven initiated three technology maturation projects directed to further development of three inventions developed at the Laboratory that appear to have commercial potential, a planar optic display, a process for treating PCB contaminated oil, and an electron beam welding system. AUI has taken title to all three inventions and will seek to license these technologies to industry to foster a commercial development. In FY95, the Laboratory initiated two technology maturation projects, one relating to PET instrumentation and the second relating to substrates for proteinases. In FY96, it is anticipated that the Laboratory will initiate one new technology maturation project.

A technical assistance program was established at the Laboratory in FY94 that enables Brook-haven's research staff to provide short term consultation to industry to assist in the solution of a technical problem. This program is available at no cost to industry and emphasizes assistance to small businesses, especially those located on Long Island. In FY94, the Laboratory provided technical assistance to four small businesses under this program; in FY95 five small businesses received assistance; and the Laboratory expects to conduct a similar number of such projects in FY96.

3. PATENT AND SOFTWARE LICENSING

Associated Universities, Inc. (AUI), the contractor-operator of Brookhaven, has the right to take title to technologies invented by Brookhaven employees at the Laboratory and to the patent rights covering such technologies. OTT has developed an active licensing program for making these AUI owned technologies readily available for commercialization by industrial companies. AUI has title to over 70 technologies, has licensed 27 of these technologies to industry, and has seen 4 of the licensed technologies commercialized as marketed products. One of the technologies that has been licensed successfully is the T7 gene expression system developed in the Biology Department. Over 185 companies have been granted licenses to the T7 technology and a number of these companies are marketing products based on this technology. Another of the Brookhaven technologies that has been successfully licensed is a method for labeling red blood cells with technetium-99m developed in the Medical Department. This technology is exclusively licensed to Mallinckrodt, Inc. and Mallinckrodt has been marketing the labeling kit based on this method since 1991.

Examples of promising technologies that at the present time AUI has available for licensing include: 1) biological materials and processes including gene expression systems, DNA sequencing processes, and recombinant plasmids for encoding restriction enzymes; 2) metal primers and coating compositions, such as improved macromolecule primers and complexed zinc phosphate conversion coatings and coating processes; 3) environmental remediation techniques, including microbial materials that are useful in removing toxic metals from contaminated wastes; 4) radiolabeled mono-clonal antibodies for diagnostic and therapeutic applications; and 5) instrumentation for the preparation of radiotracers useful in medical research and clinical applications.

OTT will continue to develop the patent licensing program as an effective route to foster com-mercialization of new technologies developed at Brookhaven. The AUI patent licensing program began in the late 1980's, and each year has seen a marked growth in royalty income from $138K in FY90 to $951K in FY95.

OTT will also continue to explore possibilities that Brookhaven developed computer software may have commercial application and thus be appropriate for copyrighting and licensing. To date, Brookhaven has not granted any copyright licenses.

BROOKHAVEN NATIONAL LABORATORY
PATENT LICENSING INCOME AND USE[a]

($ in Thousands)	1995	1996	1997	1998	1999	2000	2001	2002
Licenses								
No. of New Licenses	32	25	20	20	20	20	20	20
License Income	951	889	800	800	800	800	800	800
Use of Income								
Invention Administration[b]	137	178	175	175	175	175	175	175
Direct Patent Expenses[c]	223224	225	225	225	225	225	225	
Inventor Royalty Share	121106	100	100	100	100	100	100	
Cross-Licensing Royalty Share[d]	138	125	125	125	125	125	125	125
Scientific or Applied R&D	332	256	175	175	175	175	175	175

[a]All figures for FY 96-02 are estimated.
[b]Reimbursement to OTT for costs incurred by OTT in patenting and licensing AUI owned inventions.
[c]Patent Prosecution Expenses for AUI owned inventions, including outside counsel costs and U.S. Patent and Trademark Office fees.
[d] Royalty Share to institutions that have cross-licensing with AUI.

4. DESIGNATED USER FACILITIES

During FY 96, hundreds of scientists from industrial companies performed experiments individually or in collaboration with Brookhaven scientists at DOE user facilities located on the Brookhaven site. The vast bulk of these were at the National Synchrotron Light Source, the High Flux Beam Reactor and the Tandem Van de Graaff Accelerator. A list of companies with research teams at one of these three Brookhaven facilities is provided on the following pages. The majority of these industrial users are conducting open research under the facility's peer review process, and will publish the results of their work at Brookhaven. The fact that industrial research teams can conduct proprietary research at Brookhaven user facilities makes these facilities of extra value to industry. Thirty-five companies have active Proprietary User Agreements in place for work at the NSLS, three for work at the HFBR, and one for work at the Tandem Van de Graaff Accelerator. Industry interest in conducting either open research or proprietary research at Brookhaven's designated user facilities continues to increase. For example, the number of companies with active Proprietary User Agreements at the NSLS increased from 28 to 35 in FY96. The OTT, in conjunction with the industrial user facilities, conducts an active outreach program, disseminating detailed information concerning the research capabilities of the facilities and options available to access the facilities. It is anticipated that the level of industrial interest in the Brookhaven designated user facilities will continue to be robust through the year 2002.

INDUSTRIAL USERS AT THE NATIONAL SYNCHROTRON LIGHT SOURCE

ARIAD Pharmaceuticals, Inc.
AT&T Bell Labs
Advanced Acoustic Concepts, Inc.
Advanced Fuel Research
Aerospace Corporation
Agouron Pharmaceuticals
Air Products & Chemicals Inc.
Allied Signal, Inc.
Amgen, Inc.
Amoco Corporation
Applied Physics Technologies Corporation
Area Detector Systems Corporation
BP America
Bayer Corporation
Bio-Imaging Research, Inc.
Biological Research Center
Biosyn Technologies, Inc.
Boehringer Ingelheim Pharmaceuticals, Inc.
Bristol-Myers Squibb
Chevron Research & Technology Company
Ciba-Geigy Corporation
Containerless Research Inc.
David Sarnoff Research Center
Deltronic Crystal Industries
Dow Chemical
EB Scientific
EG&G Energy Measurements
EG&G Instruments, Inc.
Edge Analytical, Inc.
Eli Lilly and Co.
Energy Conversion Devices, Inc.
Enraf-Nonius, Inc.
Exxon Research and Engineering Co.
Frequency Electronics, Inc.
General Electric
General Instrument Corporation
Glaxo, Inc.
Hoechst AG
Hoechst Celanese Research Corp.
Hoffmann-LaRoche
IBM Research Div.
KLA
Merck & Co.
Mobil R&D Corp.
Monsanto
Montell Polyolefins USA
Moxtek, Inc.
NEC Corporation
Nicolet Instrument Corp.
Northrop Grumman ATDC
OPTOEL
Oxford Instruments
Physical Sciences, Inc.
Physitron, Inc.
Piezo Crystal Co.
Pratt & Whitney
Precision Combustion, Inc.
Procter & Gamble Co.
QEL Inc.
R&D Services, Prop.
Radiation Science, Inc.
SFA, Inc.
STI Optronic, Inc.
Schlumberger-Doll
Sci-Med
Science Applications Intl. Corp.
Siemens Analytical Instrumentation
SmithKline Beecham Pharmaceuticals
Spectra-Tech Inc.
Sterling Winthrop Inc.
Sumitomo Heavy Industries
The DuPont Company
The EXAFS Company
UOP
Unilever Research
Upjohn Co.
W.R. Grace & Co.
Westinghouse Savannah River Co.
X-ray Optical Systems, Inc.

TOTAL = 79

INDUSTRIAL USERS AT THE HIGH FLUX BEAM REACTOR

Advanced Refractory Technologies, Inc.
Air Products
AT&T Bell Laboratories
Biosym Technology
Corning Glass Company
DuPont Company
Exxon Research & Engineering
Fusion Energy Research
Genentech, Inc.
General Atomics
General Electric
General Motors Research Labs
IBM
II-VI, Inc.
Miles Laboratory
NEC Corporation
Rockwell International
Shell Research, Amsterdam
Texaco Research Center
United Occidental Petroleum (UOP)
X-Ray Optical Systems

TOTAL = 21

INDUSTRIAL USERS AT THE TANDEM VAN DE GRAAFF FACILITY

Airborne Instruments Laboratory
ALCATEL Espace (France)
Alliance Technologies, Inc.
American Telephone & Telegraph Co.
APTEK, Inc.
Ball Aerospace Corporation
Booz, Allen & Hamilton
Centre Spatial de Toulouse
Control Data Corp.
COSTAR Corporation
Defense Nuclear Agency
Diamond Materials, inc.
Epitaxx
European Space Agency
Fairchild Space Co.
General Electric Aerospace Corp.
Harris Corporation
Hirex Engineering (France)
Honeywell Space & Strategic Systems
Honeywell Solid State Electronics Ctr.
Hughes Aircraft Corporation
Hughes/Danbury Optical Corp.
IBM
Idaho National Engineering Laboratory
Jet Propulsion Laboratory
Lincoln Laboratory (MIT)
Lockheed Corporation
Loral Space Information Systems
LSI Logic, Inc.
Matra-Space (France)
Martin-Marietta Corporation
McDonnell-Douglas Corporation
Motorola, Inc.
Myers & Associates
NASA/Goddard Space Flight Center
NASA/Johnson Space Center
National Security Agency
Naval Research Lab
Northrup Grumman
Novus Technologies
Physitron Corporation
Raymond Engineering
Raytheon Corporation
Rocketdyne Corporation
Rockwell International
Scubed
SAAB Space Components Lab
Sandia National Laboratory
Santa Barbara Research Center
Spectrum Sciences
TRW
U.S. Army Strategic Def. Command
Utd Tech Microelectronics Ctr.

TOTAL = 53

In furtherance of one of its primary missions "...to conceive, design, build and operate large, complex research facilities for fundamental scientific studies...[and] providing the use of the ... facilities to the scientific community...," the Laboratory operates five designated User Facilities. These are the:

- **Alternating Gradient Synchrotron**- a 33 GeV proton accelerator used in high energy physics research; in recent years emphasis has been on research aimed at rare K-decay modes and hadron spectroscopy; starting in FY87, an important part of this program has involved heavy ions injected from the Tandem Van de Graaff;

- **High Flux Beam Reactor**- a research reactor that provides a high flux ($1x10^{15}$n $cm^{-2}sec^{-1}$max) of thermal neutrons for a variety of studies, including nuclear structure, the bulk and surface properties of condensed matter, static and dynamic critical phenomena, chemical crystallography, and the structure of natural and synthetic macromolecules;

- **National Synchrotron Light Source**- one of the world's brightest source of tuneable x-ray and vacuum ultraviolet radiation, this device is used in studying surfaces and orientation of adsorbed molecules (catalysis), structural conformation of natural and synthetic macromolecules, chemical crystallography, photochemistry, chemical reaction dynamics, and trace element compositions in samples of geological and medical interests;

- **Scanning Transmission Electron Microscope**- a device used to topographically map unstained, heavy-atom-cluster labelled specimens at a resolution of 20 A; used in studying, for instance, DNA binding proteins, multi-enzyme complexes, viruses, etc.

- **Accelerator Test Facility**- a high brightness, 70 MeV electron linac synchronized with high power laser beams; well suited for research on the interaction of electromagnetic radiation with electron bunches, including various ideas for laser acceleration, free electron lasers, non-linear electromagnetic interactions, high brightness electron sources, and novel beam diagnostics.

As can be seen from the tabulation that follows, these facilities are used predominately by outside scientists, who come to BNL to do their own research, sometimes in collaboration with BNL researchers. Regardless of the collaborative or non-collaborative nature of the investigation, the facility, ancillary equipment and its support staff are made available. In most instances, access to the facility requires that the experimenter submit a proposal that is reviewed, for scientific merit, by a panel of scientific peers. No charge is made for use of the facility as long as the work being performed is non-proprietary. Those wishing to use the NSLS for proprietary work must pay full cost recovery charges.

Several other facilities are available to outside users, but have not yet been officially designated as User Facilities and these are described in the earlier section on Core Competencies. An example is the Positron Emission Tomograph, a device for obtaining tomographic slices of the brain or whole body using coincidence detection of the positron emitters carbon-11, nitrogen-13, fluorine-18, and oxygen-15. It is used in studying human physiology and biochemistry in normal and disease states by means of suitably labelled chemical tracers. With the commissioning of a second PET device, it is anticipated that a broad constituency of users interested in gaining access to these facilities will be developed.

EXPERIMENTERS AT USER FACILITIES
FY 1995

	Number of Experimenters	Number of Organizations
RELATIVISTIC HEAVY ION COLLIDER		
BNL	77	1
Other Federal Labs	51	7
University	244	33
International	413	14
	785	55
ALTERNATING GRADIENT SYNCHROTRON		
BNL	121	1
Other Federal Labs	66	7
University	505	67
International	237	51
	929	126
HIGH FLUX BEAM REACTOR		
BNL	54	1
Other Federal Labs	21	8
University	111	46
Industry	20	14
International	67	40
Other	4	2
	277	111
NATIONAL SYNCHROTRON LIGHT SOURCE		
BNL	180	1
Other Federal Labs	295	27
University	1077	132
Industry	296	56
International	299	126
Other	59	15
	2206	357
SCANNING TRANSMISSION ELECTRON MICROSCOPE		
BNL	8	8
University	45	45
International	5	5
	58	58
ACCELERATOR TEST FACILITY		
BNL	20	1
Other Federal Labs	7	4
University	15	10
Industry	9	4
International	6	2
	57	21

F. UNIVERSITY AND SCIENCE EDUCATION

SCIENCE/MATH EDUCATION SUPPORT PROGRAMS

1. Current and Future Plans

In 1989, the Laboratory prepared a five-year Education Support Plan. Strategic thrusts abstracted from that Plan include:

Construction of a dedicated Science Education Center
Science and Technology Education for Minorities
Science Education for the Disabled
Technology Education
Science Education and Technical Assistance for the Community

While pursuing these initiatives, the Laboratory maintained its traditional dedication to **undergraduate research participation, precollege teacher enhancement** and **enrichment programs for local precollege students.** All key elements called for in the original were put in place, on schedule.

A major redirection of the Department's educational mission took place in FY96, with educational programs returning to the purview of the Office of Energy Research. We are now redirecting our efforts in response. Over the next several years, direct support for educational programs through the Office of Energy Research is expected to remain significantly below FY95 funding levels.

Such support will fall almost entirely in the college and university programs. The five year plan, however, contemplated a roughly equal balance between college/university and precollege programs, which has now been achieved. Consequently, the challenge over the next few years will be to maintain the educational momentum which has been generated by our precollege programs, while focusing direct support on reenforcing our traditional activities in undergraduate and graduate education.

Programs and plans for meeting this challenge are described below

2. Graduate, Postdoctoral and Faculty Programs

Postdoctoral appointments are made by individual Departments and provide a one- to three-year period of specialized research for recent recipients of the PhD degree.

About 4,300 guest researchers hold appointments in any given year. Many of these appointments are to university faculty and students who receive salary support from their home institutions, while BNL absorbs the cost of providing, operating and maintaining the facilities, equipment and services that they require.

Several years ago the Laboratory initiated a program entitled **Fellows in Accelerator Technology.** It is designed to satisfy those practicing scientists, generally holding a PhD in science or engineering, who wish to embark on a new career path.

An **Accelerator Engineers-in-Training** program has also recently been initiated. It is aimed at newly graduated electrical and mechanical engineers at the Bachelor level.

The Laboratory also participates in the **GEM program** for minority Master level engineering students. This provides a yearly stipend while the student is in school, plus guaranteed summer employment at BNL for several

years. The Laboratory also participates in the **National Consortium for the Physical Sciences**, a counterpart of the GEM Program.

The BNL Physics Department offers a **Research Fellowship in Physics.** This is a special fellowship intended to increase participation in the Brookhaven Physics Program by under-represented minorities. It is available to qualified postdoctoral candidates in three major areas - High Energy Physics, Nuclear Physics, and Condensed Matter Physics.

The graduate component of the **Faculty/Student Research Support Program** offers important opportunities to its participants, particularly as direct research funds are diminishing. Suspended in 1993, this effort was restored in FY94. Its continued expansion is planned.

The Laboratory continues to provide training opportunities for students holding **DOE Graduate Fellowships in Health Physics**. Until recently, these opportunities were incorporated in BNL's own graduate **Health Physics Trainee Program**, which reached a broader audience. The latter program was suspended due to funding limitations in FY93. We would like to restore it, or a modified version, as fiscal and human resources become available - particularly because of the unique field training environment the Laboratory represents.

Future plans also call for extending **research opportunities to undergraduate faculty from non-research institutions**. Such opportunities, together with the student/faculty research support program, may be seen as contributing to the enrichment of curricula at these institutions. We have also begun hosting **career days to assist undergraduates in planning their graduate education**. Linkages resulting from these initiatives will be applied in further developing our undergraduate programs - particularly with respect to underrepresented groups.

3. Undergraduate Programs

The major thrust of most of the undergraduate programs - principally the **Summer Student Program, Brookhaven Semester Program and Science and Engineering Research Semester** - is to provide participants with an intensive research experience under the close guidance of a Laboratory staff member. For many students this is their first exposure to real scientific research; the experience often influences their choice of a graduate field of study. We will continue to offer **summer intern appointments** to participants of previous High School Honors Research Programs at BNL if this program is restored.

In general, students participating in these programs live on the Laboratory grounds. Hence, the experience encompasses not only the scientific aspects of their work during the day but also includes communal living with both their peers and a mixture of graduate students, faculty and practicing scientists with varied cultural and ethnic backgrounds.

Since FY89, the Laboratory has conducted a DOE-supported **Nuclear Chemistry Summer School**. The program runs for six weeks, and includes twelve undergraduate students selected by national competition. Lectures, laboratory experiments, and tours within BNL and off-site were offered in the curriculum.

The Laboratory is pleased with its experience with a small group of **undergraduate students from Gallaudet University**. We wish to continue and expand this program.

The undergraduate component of the **Faculty/Student Research Support Program** has proven to be very valuable to its participants. Funding cutbacks led us to suspend this program in FY93; it was restored in FY94. Further expansion is a high priority, in number of participants, number of BNL facilities participating, and transfer to the classroom.

The importance of community colleges in meeting national needs in science and technology, and providing a stepping-stone to higher education was recognized in our Five-Year Plan. Enhancing the educational experience provided by these institutions will be major focus of our future efforts.

BNL now has partnerships with five community colleges and contacts with others in several technical training partnership initiatives. We are building on these to establish a broader **Community College Technical Assistance Program**. Summer and/or semester appointments are now offered for community college students - particularly those going on to four-year schools. A community college faculty/student team program was piloted in FY95. In the future we hope to offer research appointments for faculty from primarily undergraduate institutions (PUI) wishing to update their knowledge or develop courses, and to develop jointly supported in-school faculty/student projects contributing to BNL programs.

In general, undergraduate programs have maintained essentially a constant level of effort over recent years. It is the Laboratory's hope that these programs may enjoy infusion of additional funding, so that they can increase their established value in the overall scheme of math/science education. The Science and Engineering Research Semester Program, as well as the Community College/PUI initiative, is clearly ripe for expansion.

A longer term goal is an effort in telecommunications/Distance learning which will lead to the Laboratory's serving as a "virtual campus" for the university community.

4. Pre-College Education Support Programs

Initiated in 1958, our precollege level activities increased significantly in scope and size from the early 1980's through the early 1990's. Funding has been provided by, NSF, NIH, AUI, and the private sector - the Long Island Lighting Company and Metropolitan Life. Other organizations are involved in cost-sharing.

Lately, emphasis has been on consolidating our precollege programs to support systemic change in precollege education. This has lead to focusing on four strategic targets

School District Technical Assistance in Educational Reform.

BNL's precollege activities cover a broad spectrum. Made available to schools as a part of a coordinated program, their impact can be greatly increased. We have now articulated new and existing BNL activities in School District Technical Assistance (SDTA) partnerships, specifically to help local school districts implement new K-12 Mathematics, Science and Technology Standards. We then plan to use the model to form a Long Island consortium, coordinating a wide range of educational services offered by others beside BNL.

Some SDTA programs primarily involve students in laboratory research; others combine class-room activity with experimentation, or call for hands-on work outside the Laboratory. While different approaches are appropriate for different audiences, all draw on BNL's research climate.

For example, the **DOE High School Honors Research Program**, brief and intense as it is, has had an impact on a significant number of strong science students who have participated in it at BNL. This program was suspended in FY95.

Since FY88, a **Community Summer Science Program (CSSP)** has provided related experience for local high school juniors and seniors, who attend a morning lecture series and may participate in our research programs during the afternoons. Other students may utilize our resources in their own investigations. Outcomes can be rewarding; several Westinghouse Talent Search finalists have carried some or all of their research at BNL.

Our **Saturday Science Explorations** program targets unmotivated seventh and eighth grade students. It intends less to teach science than to capture the students' imaginations by demonstrating some of its wonders.

Hands-on learning activities outside the Laboratory are catalyzed by contests at BNL. The BNL Science Museum coordinates a regional chapter of the **International Model Bridge Contest**, in which high school students build bridges within standard specifications. At BNL, the bridges are tested, and prizes awarded for the highest strength-to-weight ratios. Hundreds enter annually. The Laboratory has also sponsored an **Elementary School Science Fair** for several years, organized through its Science Museum. Many schools now conduct in-house fairs to identify their entrants in the Brookhaven Fair. In the process, thousands of students, and their teachers and parents, become involved in doing science.

Effort in FY95 and FY96 focussed on linking these and other activities in SDTA partnerships. Six such partnerships are now in place and their systemic impacts are being felt - in the formation of science research clubs and courses, development of educational technology, etc. It is important note that these agreements commit the schools as well as the laboratory, and that participating District have been forthcoming both in providing human resources and in cost-sharing.

Almost no new ER funding is available for these programs in FY96. By a combination of cost reductions (such as eliminating student intern stipends and greater use of BNL staff volunteers) increased cost-sharing by SDTA schools, redirection toward lower cost options (such as equipment training and loan, and outreach via the internet) and support in conjunction with the Laboratory's public outreach activities in environmental remediation, it should be possible to maintain SDTA at a viable level. That is, one which would remain useful in at least catalyzing the development of Long-Island wide consortium, with New York State's Assistance, in FY97.

Pathways to Higher Education for Minorities and Women

BNL's long-standing commitment to underrepresented groups grew substantially under the existing five-year plan. By 1995 our programs enabled us to provide local minority students with opportunities from ninth grade through the AAS or Bachelor's degree.

Ninth and tenth graders could take part in our **Minority High School Apprenticeship Program.** They may participate in our NIH-funded **Minority High School Research Program** for the next several summers.

As a college freshmen or sophomores, students could apply to **Science and Engineering Opportunities for Minorities and Women**, administered by our Office of Equal Opportunity. If the student attends a community college in partnership with BNL, he or she may receive a summer research appointment in our **Community College Honors Program.** As a junior, he or she may apply to our **Brookhaven Semester, Science and Engineering Research Semester, and Summer Student Program** (see above).

To extend this "pipeline" concept beyond Long Island, BNL, Clarkson University and four community colleges established the **Northeast Consortium Program** (NEC) in 1991. The NEC's goal is to provide a pathway to higher education for urban minority students in the Northeast: junior high school students, recruited locally by the community colleges, participate in science enrichment activities throughout high school. They can then spend their first two college years at one of the community colleges, and complete their baccalaureate work at Clarkson, or enter Clarkson directly. In either event they would have continuing access to BNL's undergraduate programs.

In FY95, the NEC offered orientation programs at the community colleges and a science camp at Clarkson for eighth and ninth graders; versions of BNL's MHSAP program at the community colleges for ninth and tenth

graders; independent community college programs for eleventh graders; and BNL internships for undergraduates from NEC schools.

The NEC plan envisions growth to over hundred students annually in the Joint Admissions Program. BNL/DOE's support for the first two rungs of the NEC "ladder" lead AT&T to join the Consortium in FY95, and support the third rung for eleventh graders.

NEC was built on the **Environmental Education Outreach to Minorities (EEOM) Program**, started in FY90 with Bronx Community College. Initially reaching at-risk Bronx high school students annually, EEOM was replicated on Long Island, through Suffolk County Community College and the Wyandanch School District. EEOM was our pilot effort in inner-city high school outreach via com-munity college partnerships. This has become a major theme; in developing it, we instituted **Science Exploration Days** for inner city and Wyandanch students and **Mini-Semesters** including students from EEOM and NEC schools.

Another program, **Introduction to Computers**, presents basics of computer literacy to fifth and sixth graders, and their parents. The original program was based in a largely minority community and coordinated with the local school district. Later a program was established in a high minority com-munity within a second school district. Based on the growing demand, in FY95 it was planned to start a new site about every two years.

In FY95 the Laboratory also added educational opportunities for women through a new collaboration in the **Women in Science and Engineering (WISE) Program.** This pipeline program is conducted by SUNY Stony Brook with NSF support. BNL offers teaching experiments and technology projects for high school students entering the program.

These pipeline/outreach programs - particularly NEC and Education Outreach to Minorities (EEOM) - have potential as models for establishing educational pathways for underrepresented minority students and women. They test both the approach - i.e. the value of providing continuing interaction and reenforcement, and the role of community colleges in establishing such pathways - and the part BNL/DOE can play in leveraging it.

It was felt that DOE and its laboratories, with their hierarchy of precollege and university pro-grams, and growing connections with community colleges, might play a broad lead role developing the pipeline model - simply by illustrating the value of articulating existing programs. However, in FY94 the DOE/EM funding base for EEOM was eliminated. In FY96 DOE/ER funding for the precollege component of the Laboratory's other minority programs was also eliminated.

Still, strong interest remains not only in continuing but in further replicating these programs. Indeed they are proving resilient: individuals, schools and other institutions involved are demonstrating their commitment by increased cost-sharing, voluntary effort, etc. to compensate for loss of DOE funding in FY96.

Although NEC partnership institutions are not HBCU's, NEC's urban community colleges are today equally vital in serving the needs of local minority students - both after and before they enter college. NEC programs treat all precollege participants as on a pathway to college and focus on preparing them for it, reminiscent of STEP and PREP, but with greater continuity. Hopefully, future ER funding can be devoted to undergraduate level support which would also facilitate continuation of the schools' precollege outreach in the NEC pipeline. Such a commitment might also leverage AT&T's grant renewal or other funding to provide stability to all tiers.

In Environmental Education Outreach to Minorities, the laboratory is seeking seek support through collaborations with the Bay Shore School District and NSF and the EPA/Army Corps of Engineers/DOE New York/New Jersey Harbor Dredged Sediments Decontamination Demonstration Project. A hoped-for reinstatement of ER pre-college funding would leverage this effort by indicating program stability and DOE and BNL commitment to students, parents, schools and institutional partners.

Precollege Teacher Preparation

A series of in-service courses for secondary science and math teachers, initiated in 1958, continues to the present. Since the late 1970's we have also offered teachers opportunities for research participation. The boost that a classroom teacher receives from being part of the scientific enterprise is incalculable. In FY89, the DOE Teacher Research Associate Program (TRAC) emerged, as a similar program funded at BNL by the NSF was ending. A New York University (NYU) partner-ship in FY91 further extended the impact of our teacher research programs.

More recent work with teacher training centers and retired Laboratory staff led to an NSF-sponsored summer Energy and Technology Institute at BNL for elementary teachers/middle school technology teachers in FY94. The Institute provides basic content and an introductory experience in how science and technology are done.

The Laboratory also engages teachers via formulating, planning and implementing our educational programs. High school teachers act as advisors in the Honors Research Program, perform the demonstrations for junior high students and instruct in our Minority High School Apprentice and CSSP Programs. All have contributed to program development.

Experience and evaluation suggest that a research participation or MST immersion experience may be of sufficient value to a SMET teacher's professionalism that academic programs for teacher pre-paration should be modified to incorporate it. A research experience at BNL is now an accredited part of a Master Degree program in Science/Math Education offered by NYU to provide certification for minority teachers. The Energy and Technology Institute model also includes a partnership with a school of education. In FY96, it has simulated the development of what will be the first Master Degree program in MST for elementary teachers in New York State.

These programs are being considered as a model for systemic change in teacher preparation. In FY94 we held a joint conference on the question was of including research participation in academic programs offered by schools of education. how to develop such options. This idea was strongly endorsed by conference participants, who included a representative cross-section of university educators, teachers, and directors of teacher research participation programs. In a second conference, convened by the State at BNL in 1996, this model was presented in the context of preparing teachers to adopt new K-12 MST standards. Again, the reaction was positive - to the extent that the State Education Commissioner is acting on some of the ideas put forward and has commended the Laboratory for its leadership.

The FY96 level of ER and NSF support should permit us to maintain our teacher enhancement programs at a level capable of providing a template for further initiatives by the State. Hopefully, these will generate additional support for our programs as well.

Technology Education:

This effort supports "technology" as an educational discipline. Its target includes students who may not easily relate to science in the abstract, and dismiss its practical application as a career goal. We wish to extend the educational opportunities offered to four-year college students to people in two-year technical programs (see section 3), and to offer technology teachers, and their students, oppor-tunities and encouragement which so far have been largely limited to science teachers.

Since FY91 we have supported an event for middle school technology students similar to the Model Bridge Contest. It is a competition directed toward magnetic levitation (MAGLEV), organized by local technology

teachers and conducted by Hofstra University's Center for Technology Education. BNL has provided test equipment, reference material, and teacher workshops, to help develop the contest as a classroom learning activity.

We have also promoted the both replication of the model (unuversity/technology educator/local industry partnership) and the contest as a learning tool elsewhere in the State. As result, two new educational consortia were formed in FY95. These have become self-sustaining in FY96, and two new consortia will be in place in FY96. Where appropriate, we will also continue to develop and pilot other technology education modules derived from Laboratory programs.

BNL is also supporting development of strategic initiatives in technology education. The 1994 Spring meeting of the New York State Technology Education Association, held at the Laboratory, provided a focal point for further planning. As a consequence in FY95 we organized the first State-wide conference (MST-I) meeting in FY95 to address issues regarding implementation of the new State Mathematics, Science and Technology Framework. This, in turn led to the FY96 Teacher education conference mentioned above, and the outcomes described.

No new ER funding is available for precollege technology education in FY96. However, this effort has reached a point where the primary concern is concern is with dissemination. With modest staff effort, and taking advantage of the Internet, the existing MAGLEV consortia, and a Technology Education Network established by our partners at Hofstra University, it should be possible to maintain some continuity in FY96 at very little expense. Hopefully, further support will be forthcoming from other sources, including NSF, as the State's MST initiative unfolds.

5. General School and Community Outreach Programs

A **resource center** is being developed to provide an information network and educational resources derived from Laboratory research programs. Access via Internet, available to the university community and individuals for a number of years, is being extended to K-12 schools. This includes 1995 implementation of a BNL Education Home Page. An equipment training and loan program was initiated in FY95. Retired Laboratory staff also continue to volunteer as "Scientists-in-Residence" to support science education in several local elementary schools.

To promote careers in science, BNL supports a **career day program,** and develops career displays to be offered in conjunction with Laboratory events. Career events were conducted for women FY91 and FY94, and for minorities in FY92 and FY93.

The impact of the Laboratory's **Science Museum Programs** for precollege students has been enhanced through use of hands-on instructional units in the Science Museum and through outreach. These efforts led, in FY91, to a **"Magnets-to-Go"** travelling unit, keyed to the New York State elementary curriculum, which visited local school districts. Demandrose to the point where "Magnets-to-Go" reached over seven thousand students annually, but due to staff and funding cutbacks in overhead-funded programs, the travelling unit will not be used in FY97.

Rounding out our educational efforts are several general activities, scholarship programs, etc. Among them is a very active **tour program,** that centers on the Laboratory's Science Museum. It caters to all levels of the educational community, professional groups, civic groups, and the general public. Each year new items are provided in the Museum, with an emphasis on hands-on devices that demonstrate scientific principles.

The accompanying table gives number of non-BNL participants and the number of institutions represented in our educational activities for FY 1995. A bullet ( ) indicates programs with support from the DOE Office of

University and Science Education. Those activities that are directed toward underrepresented minority groups, women, or the disabled are indicated by *italics.*

ANNUAL PARTICIPATION IN BNL SCIENCE/MATH EDUCATIONAL PROGRAMS						
		FY 1995			FY 1994	
	Total	Minority	Women	Total	Minority	Women
POSTGRADUATE PROGRAMS						
Postdoctoral Fellows (salaried)	78	-	-	69	-	-
Postdoctoral Fellows (unsalaried)	649	-	-	584	-	-
Fellowship in Accelerator Technology	0	-	-	0	-	-
Research Fellowship in Physics[1]	2	0	2	2	0	2
GRADUATE PROGRAMS						
Thesis Research	695	-	-	635	-	-
Health Physics Training/Graduate Fellows in Health Physics	0	-	-	0	-	-
Accelerator Engineers-in-Training	1	1	0	3	0	1
W.C. Hamilton Scholarship	0	-	-	0	-	-
● *Science/Math Teacher Certification (NYU)*[2]	8	8	4	10	8	3
National Physical Sciences Consortium for Graduate Degrees for Minorities and Women	1	0	1	1	1	1
Graduate Degrees for Minorities in Engineering (GEM)	2	2	1			
UNDERGRADUATE PROGRAMS						
Summer Students	64	4	21	58	7	20
Summer Interns	4	0	2	2	0	1

ANNUAL PARTICIPATION IN BNL SCIENCE/MATH EDUCATIONAL PROGRAMS						
		FY 1995			FY 1994	
	Total	Minority	Women	Total	Minority	Women
Gallaudet University Program						
Students	3	1	0	4	1	1
Faculty Interpreter	1	0	1	1	0	1
Brookhaven Semester Program:						
Faculty	1	1	0	0	0	0
Students	2	2	0	3	3	2
Science and Engineering Research Semester	40	1	15	41	3	15
HFBR/NSLS Faculty-Student Research	46	2	6	78	-	19
Southampton College Co-op/Intern Program	30	0	18			
Science and Engineering Opportunities for Minorities and Women.	30	19	23	26	14	20
Department of Advanced Technology - MIT Nuclear Engineering Intern Program	0	-	-	0	-	-
Nuclear Chemistry Summer School	11	0	4	11	0	4
● *College Mini-Semester*	14	14	6	8	8	5
Guest Research Assistants	662	-	-	534	-	-
Community College/Technology Education Programs:						
Community College Summer Students	8	8	2	5	5	2

ANNUAL PARTICIPATION IN BNL SCIENCE/MATH EDUCATIONAL PROGRAMS						
		FY 1995			FY 1994	
	Total	Minority	Women	Total	Minority	Women
Suffolk County CC Work-Study Students	6	6	1	4	1	1
Community College Faculty-Student Research (new, FY95)						
Faculty	2	0	2	-	-	-
Student	4	1	1	-	-	-
Technician Training Program for Minorities and Women.	2	1	1	-	-	-
Special Programs:						
Renate Chasman Scholarship	1	0	1	1	0	1
Facility Tour Program for College Groups	1875	-	-	1400	-	-
Graduate School Career Fair (approximate - new, FY95)	40	-	-	-	-	-
PRECOLLEGE PROGRAMS						
DOE High School Honors Research Program	0	-	-	60	4	24
Pathways in Science Education for Minorities, Women and Inner-city Students:						
● *Northeast Consortium for Minorities*	167	167	97	152	152	88
● *Environmental Education Outreach for Minorities*	36	36	19	60	54	21
NIH Minority Summer Research Apprenticeship	13	13	6	11	11	5
Minority High School Summer Apprenticeship	41	41	24	38	38	22
High School Mini-Semester	14	14	9	16	16	5

ANNUAL PARTICIPATION IN BNL SCIENCE/MATH EDUCATIONAL PROGRAMS						
		FY 1995			FY 1994	
	Total	Minority	Women	Total	Minority	Women
Introduction to Computers	94	26	43	140	54	61
Science Exploration Days (inner city students)	25	25	17	410	410	-
Youth on Campus	8	0	8	16	15	12
High School Co-op	11	7	9	4	3	3
Women in Science and Engineering (SUNY-SB - new in FY95)	30	0	30	-	-	-
Student/School District Educational Assistance Programs:						
Community Summer Science	38	3	18	38	2	19
Career Awareness Days	0	-	-	20	-	20
Saturday Science Explorations						
Students	459	69	230	487	-	-
Teachers	49	-	-	32	-	-
Magnets-to-Go	7755	-	-	6682	-	-
Elementary Science Fair						
Students	950	-	-	720	-	-
Teachers	379	-	-	318	-	-
Scientists-in-Residence (approximate)	150	-	-	150	-	-
BNL Model Bridge Building Contest						

ANNUAL PARTICIPATION IN BNL SCIENCE/MATH EDUCATIONAL PROGRAMS						
		FY 1995			FY 1994	
	Total	Minority	Women	Total	Minority	Women
Students	300	-	-	304	-	-
Teachers	38	-	-	38	-	-
High School Science Bowl	267	-	60			
Precollege Teacher Enhancement Programs:						
Systemic Initiative in Teacher Education (SITE) - Annual BNL Conference (2nd Annual: 10/30/95)				38	13	15
Teacher Research Associates	19	1	17	25	2	5
National Teacher Enhancement Program	32	7	22	25	0	13
● *Environmental Education Outreach for Minorities*	0	0	0	0	0	0
NIH Summer Research Apprenticeship	1	1	0	3	3	0
● *Minority High School Summer Apprenticeship*	2	1	1	0	0	0
Precollege Technology Education Programs:						
Math/Science/Technology Integration (MSTI) - Annual BNL/NY State Conferences	80	2	30	300	-	-
Northeast MAGLEV Consortia	480					
Students (approximate)	480	-	-	300	-	-
Teachers (approximate)	35	-	-	-	-	-
Technology Educators' Workshops	25	1	1	30	1	0

ANNUAL PARTICIPATION IN BNL SCIENCE/MATH EDUCATIONAL PROGRAMS						
		FY 1995			FY 1994	
	Total	Minority	Women	Total	Minority	Women
SCHOOL CLASSES AND GENERAL PUBLIC						
Science Museum Discovery Tour Program (gr K-3)	7401	-	-	5780	-	-
Science Museum - Investigations in Science (gr 4-6)	4946	-	-	-	-	-
Science Museum School Tour Program (gr 7-12)	2729	-	-	6088	-	-
Family Site/Science Museum Tours (Summer Sundays)	4365	-	-	9240	-	-
Science Museum Teacher/Museum Seminars	30	-	-	-	-	-
Science Museum "Discoveries-to-Go" - visits to Schools	607	-	-	742	-	-
Science Museum - Adult Groups	1076	-	-	-	-	-
New York State Student Mentoring Program (new, FY 95)	37	11	25	-	-	-

(1) A bullet ( ) indicates programs with support from the DOE Office of University and Science Education.

(2) Activities directed toward underrepresented minority groups, women, or the disabled are listed in *italics.*

VI. HUMAN RESOURCES

A. LABORATORY PERSONNEL

The Laboratory employs a total staff of 3,261. This consists of Scientific personnel representing approximately 21 percent, Engineering personnel comprising 16 percent, Management and Administrative personnel at 12 percent, other Professional personnel at 11 percent, Technicians at 13 percent, and all other support, including bargaining unit employees at 27 percent.

Scientific personnel at the Laboratory include specialists in a variety of physical and biological science disciplines, reflective of the multi-disciplined research at the Laboratory. They are, as a group, exceptionally motivated in their work and proud of their affiliation with the Laboratory. Major scientific disciplines represented are physics, biology, chemistry, computational science, and medical research. Major engineering disciplines include chemical, electrical, mechanical and nuclear. There is also a wide variety of specialties represented within the environment, safety and health disciplines. Employees typically possess highly specialized knowledge in one or more concentrations within their disciplines. The Scientific Staff capitalizes on the broad knowledge base resident at the Laboratory to develop their ideas. The mix of short term visitors, facility users, and other temporary appointments and long-service staff contributes to a blending of knowledge that provides both stability in programs and churning of ideas for a productive and stimulating environment.

It is expected that an increasing percentage of the scientific workforce will be foreign-born, because of the ever increasing percentage of foreign-born PhDs graduating from educational institutions in the United States, and immigration law quotas favoring highly skilled workers. Immigration activity at BNL is commensurate with these trends and contributes to a mix of diverse cultures at the Laboratory. Entry level personnel for the entire workforce will be composed increasingly of women and minorities. BNL strives to employ this diversity to yield a more productive workforce by maintaining a community atmosphere.

The workforce also consists of a large number and wide variety of technical and administrative personnel. Technical personnel perform support work in a range of disciplines similar to the scientific and engineering population. There is also a full range of business disciplines which include financial, information systems, human resources, program management, contracts, public relations, publishing, and security, as well as skilled craft and other support disciplines. Many work disciplines, such as educational programs, technology transfer and technical information, have a unique character in a research institution like BNL.

There are several reasons for the significant level of effort which is directed toward training of the Laboratory's highly-skilled workforce. Training of Laboratory personnel includes technical, Environment, Safety & Health (ESH), and specific job skills training, as well as administrative and compliance training. The Training Office in the Human Resources Division coordinates the implementation of training site-wide, and interfaces with other Laboratory organizations that serve as providers of training in their areas of specialty. They are also progressing on the implementation of a centralized training database. The Laboratory is in the process of performing job training analyses of all functional jobs to document training requirements. The initial emphasis for this activity is ESH training. Due to the continuing increase in training requirements affecting all areas, the Laboratory is considering the construction of a Visitor/Training Center. In addition to providing adequate training facilities, a focal point for training, and more efficient use of training resources, this center could provide better control of access to the site.

The Training Office continues to offer courses to employees labwide in the areas of supervision, management, communication, and employee development. Employees may enroll in college and certification programs which are provided by local educational institutions in fields selected for their value to the Laboratory. The Division

continues to support the Craft Apprentice program and is piloting a Career Mentor program for future implementation Labwide. There has been a steady increase in the demand by Laboratory management and staff for training and education.

Towards its goal of recognizing excellence, the Laboratory continues to administer a set of reward programs for individual employees. The programs are directed at specific achievements, namely excellence in research and development, long term outstanding contribution by the Laboratory support staff, short-term outstanding accomplishments by support personnel, and perfect attendance by weekly employees. These awards are well received by employees and managers, however, other specific needs have been identified for which expanded avenues of reward programs may be the solution. Modifications to award programs to address changing priorities and some specific needs will be facilitated by the increased flexibility in AUI's contract with DOE.

BNL's competitive market position was affected by the DOE-imposed salary freeze in FY94. It is important that key employees in all areas be retained through fair compensation, and that the salary program enhances organizational performance and ensures equity at minimum cost. The Laboratory continues to monitor both terminations and turndowns of employment offers to evaluate the effect of the Laboratory's lower market position resulting from the freeze, and is investigating the advantages of adopting some form of additional lump sum compensation in addressing the compensation program goals. BNL has committed, in the AUI contract, to examine and propose an incentive compensation program which will be tied to individual and contract performance. The incentive program will be developed within the constraints of the Secretary of Energy FY94 salary freeze which prohibits recouping lost market position for five years.

The Laboratory seeks to select and place job candidates in accordance with affirmative action goals and job requirements. Some present and future recruiting efforts are expected to be helped by the continued slack in the local economy. While the local area serves as an adequate source of individuals with a wide set of skills, many of the specialties at the Laboratory must be drawn from a wider geographical area. In addition, the local cost of living, and the attraction of healthy economies in other areas of the nation, drive younger job seekers with fewer local roots away from Long Island, depleting some of the local talent pool. BNL conducts several intern programs for entry level staff to nurture the unique knowledge base required in some of the programs at the Laboratory.

The Laboratory continues to address staffing demands through internal re-deployment as well as external searches through active recruiting, targeted advertising in specialized journals and newspapers with national exposure, and use of the World Wide Web. Use of relocation policies, competitive salaries for all employee groups, particularly those currently experiencing strong demand, and the application of computer technology to disseminate information on Laboratory openings all contribute to an aggressive recruitment posture. Affirmative Action goals are given strong consideration in developing staffing plans. In accord with DOE direction, BNL gives preference in filling job openings to employees of other DOE contractors affected by staff reductions by referring to the automated DOE database, JOBS.

The staffing challenge is further complicated by reductions in force necessitated by budget cuts or research program life cycle changes. The Laboratory endeavors to maintain staff capabilities at a high level when downsizing occurs. Senior management approval of all volunteers under workforce reductions helps to ensure that critical skills are retained. The long term impact of human resource losses is minimized by targeting voluntary severance benefits to minimize the unnecessary loss of specialized knowledge. The Laboratory seeks to anticipate situations where current staff members are displaced and transferred to identify instances where retraining would be a cost effective endeavor.

The downsizing process is also respectful of maintaining a systemically ethnically diverse workforce. Toward this end, all involuntary staff reductions are reviewed formally by a committee which includes adverse impact among its evaluation criteria.

The operation of the Child Development Center on site has enhanced the work life of working parents and has been helpful in the retention of staff members. Despite having already expanded the capacity of the center beyond the initial capacity of 87 up to the current level of 108, there is still strong demand for openings. The waiting list for the Center numbers approximately 105. This increased demand by employees for space for their children in the Child Development Center has created the need to investigate further expansion of the Center's capacity.

The Laboratory, like all employers, has realized the need to control the rising costs of employee benefits. The Laboratory reviews its benefits programs on an ongoing basis and strives to provide programs that address the needs of employees and retirees and thereby enhance performance while containing costs. Use of precertification and reimbursement based on reasonable and customary rates are measures taken by the Laboratory in a trend to involve all employees in the responsibility for controlling medical insurance costs. In addition, increased employee and retiree contributions toward their medical insurance have been implemented. Changes in paid time off, such as vacation and sick leave, have also been employed to reduce costs.

The Laboratory is currently reviewing managed medical care programs and alternate plan designs to achieve a comprehensive program with cost-containment features. A managed dental care program which provides dental services through a network of dentists has been in effect for over 3 years. The goal of the program, to reduce dental costs for both employees and the Laboratory, has been realized. Based on this success, it is expected that similar savings can be achieved with medical plans under this approach. The provision of competitive health insurance plans for attracting and retaining employees, balanced with a concern for the cost of these plans, will continue to be a major challenge.

The Laboratory recognizes the changing demographics of the employee population and their financial and health care needs. We anticipate that changes in Social Security will cause more employees to postpone retirement and thereby increase the likelihood of an aging workforce. One response has been the offering of long-term care insurance to employees, with the cost of the insurance borne by the employee. This insurance, which became effective January 1, 1994, is available to active employees and their spouses, parents, in-laws, and retirees and their spouses. It provides financial help for custodial care for people who suffer a chronic disease or long-lasting disability. Services can be provided in a nursing facility, adult day care center, or at home. The Laboratory has also expanded its retirement planning seminars to include financial planning for employees of all ages. The goal is to provide employees with tools to enable them to make appropriate decisions for their future.

Another demographic that affects employee health care needs is the number of BNL staff working under the J-1 visa program. This program requires that foreign visitors obtain insurance covering repatriation and medical evacuation. BNL has arranged for insurance that affected BNL staff may obtain to meet this requirement.

The Laboratory recognizes the continued growth of laws and regulations in support of the family, while also acknowledging some potential in Congress for reversal of this trend. It also seeks the cohesive work environment and increase in productivity and efficiency that is generated through work policies that help employees address personal issues. The Family and Medical Leave Act of 1993 required the Laboratory to review its policies and practices with respect to those individuals with needs for leave because of a new child, to care for family members with serious health conditions, or the employee's own serious health condition. After some minor changes which have been implemented, BNL policy provides for the accommodation required under the Act. In addition, limited use of sick leave accruals for the care of an ill family member is now permissible.

As a further step in responding to the personal needs of employees, the Laboratory is investigating the potential of alternative work schedules. The challenge will be to address employees' needs while also seeking to improve their productivity and provide equitable treatment. Changes to labor laws that are now being contemplated by the government are being monitored to determine the best approach to providing flexibility while minimizing cost. In addition to flextime, BNL is investigating alternative work arrangements, such as compressed

workweek and telecommuting, which also help address the travel reduction requirements of Amendments to the Clean Air Act of 1990, while helping employees attend to personal needs.

The Laboratory has recognized an increased need to track information and assign responsibility for the activities of a steadily increasing number of individuals who visit the Laboratory to collaborate on research or work at any of the user facilities, as well as those who perform services on-site for the Laboratory. BNL's commitment to provide a safe work environment has resulted in the implementation of systems and methods for ensuring that these individuals are properly trained, perform their work safely, and adhere to Laboratory policies and procedures.

The increased need to provide information for planning and decision making in managing the Laboratory's human resources has created a requirement for an improved information system. The Laboratory installed a modern human resource information system to enhance the ability to develop and use employee knowledge, skills and abilities, and to provide competitive, fair and consistent treatment of employees in employment and compensation. Add-on modules, such as a salary review system and a year-round interface for Laboratory managers and supervisors to access and change selected Human Resource information, have been developed to make the system more useful. A module to track the status and bill for benefits for terminated employees, including retirees, is now being developed.

LABORATORY STAFF COMPOSITION
As of September 9, 1996

	PhD		MS/MA		BS/BA		OTHER		TOTAL	
	#	%	#	%	#	%	#	%	#	%
PROFESSIONAL STAFF										
Scientist	484	70.7	91	13.3	92	13.4	18	2.6	685	21.0
Engineers	125	23.6	194	36.6	185	34.9	26	4.9	530	16.3
Management & Administrative	37	9.7	87	22.8	114	29.8	144	37.7	382	11.7
Other Professional	6	1.7	14	3.9	52	14.3	291	80.2	363	11.1
SUPPORT STAFF										
Technicians	1	0.2	6	1.4	54	12.5	372	85.9	433	13.3
Other Support	0	0.0	13	1.5	59	6.8	796	91.7	868	26.6
LABORATORY TOTAL STAFF	653	20.0	405	12.4	556	17.0	1647	50.5	3261	100.0

B. AFFIRMATIVE ACTION AND EQUAL EMPLOYMENT OPPORTUNITY

The Diversity Office, which reports within the Human Resources Division, is responsible for the Laboratory's Affirmative Action, Equal Employment Opportunity, Diversity and Women's Programs.

Brookhaven has a history of a strong commitment to its employees. It recognizes that all of its employees contribute to the Laboratory's success in achieving its core missions. Employee teamwork, empowerment and mutual respect are the basis for fostering an innovative and creative workplace.

A workplace which has the reputation for valuing and utilizing the differences of its employees is a positive recruitment tool for attracting a quality employee. Equally as important as recruitment, is retention of quality employees. Therefore, the Laboratory has developed a Strategic Diversity Plan whose key elements address these issues.

One of the key elements of Brookhaven's Diversity Plan is to evaluate and define its current management policies, practices and work systems to ensure that they support the needs of its diverse workforce and are in compliance with Equal Opportunity Employment Laws.

Another approach under consideration to employ workforce diversity effectively is the administration of a self analysis of the Laboratory culture with regard to its gender, race and cultural and organizational differences, and utilizing this information to establish a basis for developing and expanding the remaining elements of the Diversity Plan.

To oversee the Diversity Plan, and to advise the Diversity Manager, the Laboratory has established a Diversity Management Steering Committee. The nine member committee consists of top Laboratory scientific and business

managers. Their goal is to ensure that ethnic, cultural, gender and organizational differences are recognized and incorporated into the Laboratory's culture. The Committee is responsible for encouraging the support by all employees in the initiatives developed by the Diversity Office. The Committee plans to establish a Diversity Achievement Recognition Program to recognize employees who have made extraordinary efforts in meeting the Laboratory's diversity objectives.

The Diversity Manager reports periodically to the Committee on the status of programs and the Laboratory's Affirmative Action and Diversity Plan's Goals. The Affirmative Action Plan is the instrument which drives the diverse composition of the workforce because it seeks to ensure that underrepresented classes of people are represented in the workforce. A particular emphasis of the Plan is increasing the number of minorities and women and people with disabilities into the scientific, professional and technical job categories. Recruitment activities such as college job fairs, special advertising in minority/women and magazines targeting people with disabilities, career day programs, high school cooperatives, summer interns, and educational programs are developed jointly between the Diversity Office and the Employment staff.

In an effort to break the Glass Ceiling (eliminate historical barriers to limitations of womens' career progression), and to diversify all levels of management, mentoring programs are being piloted in the some BNL organizations. Professional networks are encouraged for women and minorities to also assist them in their professional development.

For a diverse workforce to be effective, understanding of differences and communication are essential. Through the Training Office, training programs will be targeted to these issues in order to expand the awareness of managers, supervisors and employees to cultural, gender and race differences. Such programs will include AIDS Awareness, Americans with Disability Laws, and Sexual Harassment.

Specialized training will be conducted by the Diversity Office for the Equal Employment Opportunity Representatives who are the liaisons between the Diversity Office and the employee, to enhance their effectiveness in identifying and resolving problems.

The Women's Program Coordinator, whose charge it is to identify, develop and help implement policies and procedures which enhance opportunity, remove barriers and assist women in achieving career development, will continue to be a part of the Laboratory's organization.

The Women's Program Advisory Board has been responsible for developing programs which support and value women's work. They have been successful for developing a child care user database; a parent's guide to child care insurance and safety; and project WISE (Women In Science Excel), a Brookhaven and SUNY Stony Brook collaboration in which academically talented female students are provided with hands-on research experience and advice from female mentors.

1991
EQUAL EMPLOYMENT OPPORTUNITY

Occupational Codes	Total		Minority Total		White		Black		Hispanic		Native American		Asian/Pac. Islanders	
Gender	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Officials/ Managers	567 87.8%	79 12.2%	52 8.0%	11 1.7%	515 79.7%	68 10.5%	19 2.9%	2 0.3%	8 1.2%	1 0.2%	0 0.0	1 0.2%	25 3.9%	7 1.1%
PROFESSIONAL STAFF														
Scientists & Engineers	809 85.1%	142 14.9%	153 16.1%	39 4.1%	656 69.0%	103 10.8%	12 1.3%	3 0.3%	11 1.2%	4 0.4%	1 0.1%	0 0.0%	129 13.6%	32 3.4%
Management & Administrative	262 72.2%	101 27.8%	13 3.6%	9 2.5%	249 68.6%	92 25.3%	10 2.8%	6 1.7%	3 0.8%	1 0.3%	0 0.0%	0 0.0%	0 0.0%	2 0.6%
Technicians	414 94.3%	25 5.7%	41 9.3%	7 1.6%	373 85.0%	18 4.1%	21 4.8%	5 1.1%	13 3.0%	1 0.2%	2 0.5%	0 0.0%	5 1.1%	1 0.2%
All Other	567 58.3%	406 41.7%	139 14.3%	98 10.1%	428 44.0%	308 31.7%	89 9.1%	69 7.1%	38 3.9%	24 2.5%	5 0.5%	2 0.2%	7 0.7%	3 0.3%
Totals	2619 77.7%	753 22.3%	398 11.8%	164 4.9%	2221 65.9%	589 17.5%	151 4.5%	85 2.5%	73 2.2%	31 0.9%	8 0.2%	3 0.1%	166 4.9%	45 1.3%

1996
EQUAL EMPLOYMENT OPPORTUNITY

Occupational Codes	Total		Minority Total		White		Black		Hispanic		Native American		Asian/Pac. Islanders	
Gender	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Officials/ Managers	496 86.3%	79 13.7%	40 7.0%	14 2.4%	456 79.3%	65 11.3%	9 1.6%	7 1.2%	7 1.2%	2 0.3%	0 0.0%	0 0.0%	24 4.2%	6 1.0%
PROFESSIONAL STAFF														
Scientists & Engineers	786 85.2%	136 14.8%	161 17.5%	39 4.2%	625 67.8%	97 10.5%	10 1.2%	2 0.2%	15 1.6%	3 0.3%	0 0.0%	0 0.0%	136 14.8%	34 3.7%
Management & Administrative	309 66.7%	154 33.3%	31 6.7%	20 4.3%	278 60.0%	134 28.9%	16 3.5%	9 1.9%	5 1.1%	4 0.9%	1 0.2%	0 0.0%	9 1.9%	7 1.5%
Technicians	402 92.8%	31 7.2%	40 9.2%	5 1.2%	362 83.6%	26 6.0%	21 4.8%	4 0.9%	12 2.8%	0 0.0%	2 0.5%	0 0.0%	5 1.2%	1 0.2%
All Other	480 55.6%	384 44.4%	119 13.8%	97 11.2%	361 41.8%	287 33.5%	78 9.0%	70 8.1%	32 3.7%	22 2.5%	3 0.3%	2 0.2%	5 0.7%	3 0.3%
Totals	2473 75.9%	784 24.1%	391 12.0%	175 5.4%	2082 63.9%	609 18.7%	134 4.1%	91 2.8%	71 2.2%	31 1.0%	6 0.2%	2 0.1%	180 5.5%	51 1.6%

VII. ENVIRONMENT, SAFETY AND HEALTH (ES&H)

A. ES&H Goals and Objectives

The vision of BNL management for our ESH program is to achieve the same level of success in ESH that has been achieved in BNL's scientific endeavors; to merge the compliance of ESH requirements with the overall scientific programs through a structure of: (1) effective ESH management; (2) trained and qualified personnel; (3) compliance with all requirements necessary for the protection of the safety and health of the public, site workers, and the environment; and (4) ensuring that there is continuous ESH program improvement. ESH will continue to be an integral part of the BNL culture and will continue to contribute to the success of the Laboratory's mission.

The specific long-range performance goals established by the Laboratory are:

1. Operating and research organizations will conduct all activities in a manner that ensures safety of the worker and protection of the environment in balance with programmatic output;

2. All activities will be conducted in compliance with environmental regulations.

3. Employees will be qualified by training and experience as required in the *Laboratory Training Policy* to perform their assigned duties safely;

4. The hazards classification of Laboratory facilities and activities will be established and, where appropriate, recorded in safety analysis documents. An envelope of safe operation, with the basis documented, will exist where meaningful;

5. Workplaces will meet Occupational Safety and Health Act (OSHA) standards.

6. Departmental/divisional management will have good assurance from the type and frequency of measurements that personnel are reasonably protected from the possibility of adverse effects due to hazardous chemicals and materials, non-ionizing radiation, noise, heat stress and other potential workplace hazards;

7. Radiation protection efforts will be appropriate to protect persons from unnecessary exposure to radiation, minimize contamination, and ensure the proper control of radioactive material;

8. Buildings and other structures will present no unacceptable risk to the occupants as the result of any credible fires;

11. Information on ESH and Safeguards and Security issues coming from sources outside of the operating and research organizations will be evaluated for its specific applicability to the organization's activities with responsive actions undertaken where appropriate;

12. Reportable occurrences experienced by the departments/divisions will be promptly identified, evaluated or investigated, and reported to Laboratory management (and to DOE where required) and appropriate actions taken to identify and correct root causes;

13. All commitments for ESH corrective actions made to management will be entered into a tracking system and followed to completion with progress periodically fed to the tracking system;

14. Supporting services from the Safety and Environmental Protection Division (SEP) and other support organizations will provide quality service in a timely manner to support the safe and environmentally sound activities within the programmatic units; and

15. Departments/divisions will continually review emissions/effluents, characterize inputs to these discharges, and strive to minimize/eliminate any environmental contaminants associated with these releases.

B. Current Conditions

The Laboratory is committed to maintaining compliance with ESH requirements while carrying out its missions in research and development. The Laboratory responds to New York State Department of Environmental Conservation (NYSDEC) in several areas, including requirements related to the Clean Air Act, the Clean Water Act and the Resource Conservation and Recovery Act (RCRA). As a federal facility, it is required to meet all federal requirements, such as those administered by the Environmental Protection Agency (EPA) and OSHA. In an effort to be responsive to local environmental concerns, BNL has a cooperative agreement with Suffolk County to meet the technical requirements of local environmental codes. Since 1989, the Laboratory site has been listed on the EPA National Priority (Superfund) List and has worked to identify, characterize, and initiate remedial actions at several areas of environmental concern. In February of 1992, DOE, EPA, and NYSDEC signed an Interagency Agreement (IAG) which provides the framework for conducting Superfund activities. Discussions of Superfund activities are presented in Section E, Environmental Management and Pollution Prevention.

Over the last several years, intensive efforts have been expended to increase the safety awareness of all employees. A policy and procedures manual was developed to codify the ESH program and define its implementation in each department and division on site. Training of all employees has been emphasized, particularly in the ESH areas. Conduct of Operations, Quality Assurance, and Maintenance activities related to safety and health are and will continue to be implemented using a hazard-based approach.

The Laboratory is faced with the increasing costs of meeting all ESH requirements. New ESH actions continue to be established, such as codification of Parts 834 and 835, new non-nuclear facility requirements, codification of new and revised Clean Air Act requirements, and other Safety and Health program demands.

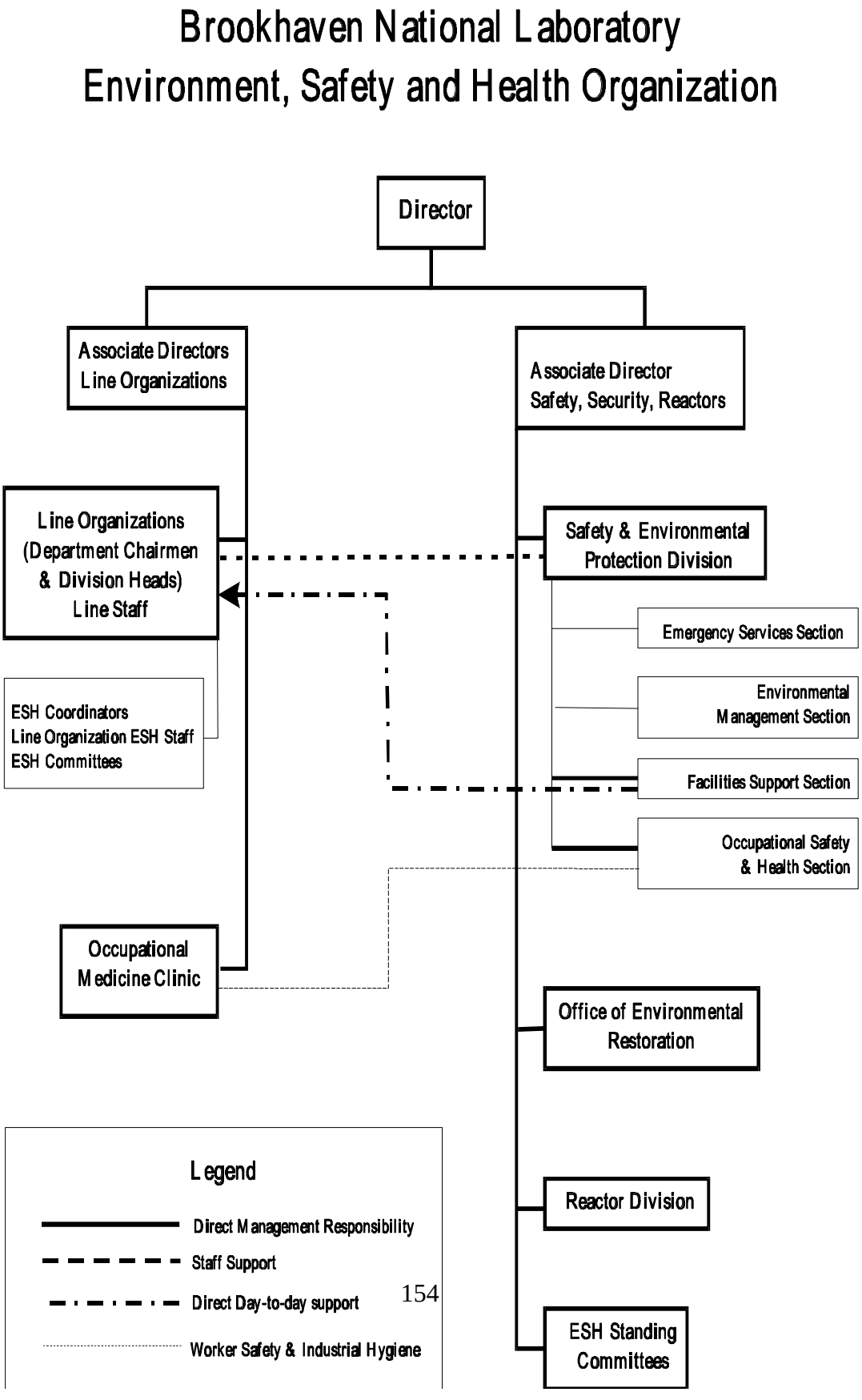
Past Laboratory operations which pre-dated modern environmental legislation such as the Clean Water Act, Resource Conservation and Recovery Act, and Comprehensive Environmental Response, Compensation, and Liability Act, resulted in the release of contaminants to the environment. As investigations delineate the movement of these contaminants in the environment, these past practices have captured public attention. The community reaction to BNL has been one of general mistrust. The Laboratory is working hard to regain trust through direct community interaction. This effort is growing and evolving rapidly and is expected to continue to be an important activity for the foreseeable future. The challenge for BNL will be to balance these needs for ESH program performance and community interaction/education while maintaining its forefront position in basic and applied research and development.

C. ESH Policies, Organization, and Management

The Director of the Laboratory has primary responsibility for issuing standards and policy in all areas of Laboratory operations. Day-to-day implementation of these policies and standards is carried out by the Director with assistance from a Deputy Director and eight Associate/Assistant Directors. The Associate

Director for Reactor, Safety, and Security is responsible for approving ESH goals, policies, standards, and guides and the implementation of the Laboratory's ESH requirements. Development of most ESH policies and standards for this Associate Director are the responsibility of the Safety and Environmental Protection Division. This Division also provides staff ESH support and ESH facility operations support. The Director and Associate Director for Safety are also advised by five standing ESH committees: ESH Committee; ESH Management Advisory Committee; Cryogenics Safety Committee; Electrical Safety Committee; and Reactor Safety Committee. Other support operations to upper Laboratory Management include the Office of Environmental Restoration which is responsible for site environmental remediation activities, the Occupational Medicine Clinic which is responsible for establishing and maintaining an occupational medicine program, and the Reactor Division which is responsible for ensuring experiments conducted at BNL High Flux Beam Reactor and Medical Research Reactor are conducted in a manner consistent with policies and practices that protect the environment and the health and safety of the public and workers. Each program office also has an ESH Coordinator/Team that interface(s) with the research/worker community, program management offices, and the directorate to ensure operations are carried out in a manner consistent with the Laboratory ESH policies and standards. The line organization in place to manage and promote ESH policies and standards is presented in Figure VI-1.

Figure VI-1:


Brookhaven National Laboratory
Environment, Safety and Health Organization
Director
Associate Directors
Line Organizations
Associate Director
Safety, Security, Reactors
Line Organizations
(Department Chairmen
& Division Heads)
Line Staff
Safety & Environmental
Protection Division
Emergency Services Section
Environmental
Management Section
Facilities Support Section
Occupational Safety
& Health Section
ESH Coordinators
Line Organization ESH Staff
ESH Committees
Occupational
Medicine Clinic
Office of Environmental
Restoration
Reactor Division
ESH Standing
Committees
Legend
Direct Management Responsibility
Staff Support
Direct Day-to-day support
Worker Safety & Industrial Hygiene

To achieve BNL's ESH long range goals and work toward our vision, the following strategies are considered in all planning and decision-making:

1. Determine the scope and applicability of all new policies and requirements promulgated by DOE and other regulatory authorities at the federal, state, and local level;

2. Implement new requirements within operating organizations to ensure both proper identifica tion of the hazards and risks associated with organization mission and proper application of the operating organization's resources;

3. Assure our basic direction and allocation of resources is focused on the strategic plan through proper planning and prioritization; and

4. Seek close interaction and cooperation between the research and operating organizations and the staff ESH support organizations in the development and implementation of ESH requirements.

An essential part of meeting the Laboratory's goal of a sustained and continuously improving ESH culture is the implementation of an effective internal program evaluation process. The multi-tiered ESH program review process involves evaluations ranging from program specific to Laboratory-wide. The first tier of evaluation consists of an internal department/division review utilizing primarily line manage-ment and workforce members. Inspection results are communicated directly to the department/ division manager. The second tier involves an ESH program review of individual departments/ divisions a minimum of once every three years by members of the SEPD. Results of this review are communicated to the department/division manager, responsible directorate program manager, and the BNL Laboratory Director. The third tier of program review involves a major Laboratory-wide ESH principle(s) that is reviewed by a party outside of the Laboratory. This review is coordinated by the Vice President of ESH for Associated Universities, Inc. Results of this review are presented to the Department of Energy, cognizant Laboratory ESH management, and Associated Universities, Inc.

Each of these reviews may identify issues that, when resolved, would strengthen the current ESH program. These issues are identified and tracked for each tier of program review. The first tier pro- gram issues are tracked by the department/division. The tracking and resolution of these issues are reviewed by the SEPD during the second tier review. Issues identified in second and third tier program reviews are tracked by the SEPD. Action plans devised to address the issues are set out in a schedule of commitments which are tracked with the issues. Review of issues and commitments are updated quarter-ly by the SEPD through communication with the assigned issue manager. These reports are reviewed by the Associate Director for Reactor, Safety, and Security.

Program review and update are essential elements needed to strive toward ESH excellence. Annual self assessments are performed by each department/division which take into account status and trends of ESH in the program, issues identification and resolution related to each facet of the multi-tiered program review, and future direction of the program. Summaries for each of these self assess ments are reviewed by the SEPD and the Associate Director for Reactor, Safety, and Security. This information is utilized to evaluated progress against Laboratory ESH goals and visions and to modify policies, goals, and visions to reflect current information.

To accomplish the policies, goals, and work toward the visions provided, the Laboratory in FY 1995 expended $26.48 million in operating funds which supported 267 FTEs. These expenditures are further

augmented by direct funded programs, primarily through EM, which contribute to the base ESH program at the Laboratory.

D. ESH Plans and Initiatives

Through the ESH Management Planning process BNL has identified significant ESH risk issues, and proposed actions to resolve/control these risks. We believe we have been successful in that pro-cess, and that there are no significant ESH risks that are not accounted for in this plan. Currently identified significant ESH risks are or will be addressed under the major planning assumptions and the risk prioritization basis in this plan. We also believe that important areas defined in EH and CSO strategic guidance are enveloped by our plan, and that continued funding at current levels will allow us to continue with our improvement activities that "represent good investments in risk management and prevention".

The six most important ESH risk management issues facing BNL during this planning period are described below. This is not simply a list of highest ranking ADSs, but the most important ESH improvement initiatives currently being undertaken by BNL, with significant support from the DOE-Energy Research Office of Laboratory Management (ER-80).

1. IH Chemical Management System - ADS# E94D0003: This activity provides for a chemical inventory of departments/divisions at BNL, including the identification of existing chemicals, the application of bar code labels to all chemical containers currently present at the Labora-tory, and the tracking of new and existing chemicals in a computer-based chemical inventory management system. This system will assist the Laboratory in providing hazard information, generation of compliance reports, and waste minimization through reductions in chemical purchases. As of September 1, 1996, more than 60,000 chemical containers have been inventoried and bar coded. New chemicals are also being inventoried and bar coded prior to distribution on site. It is expected that the site wide inventory will be completed and the system will be fully operable by the end of FY97.

2. Worker Safety Enhancement Initiative - ADS# E95D0003: This activity is a three year effort geared to enhance worker safety at BNL. The major tasks to be completed under this program are the development of approximately 20 computer-based training modules, identification of high risk tasks and facilities with completion of plans to improve worker safety in the identi-fied area, Worker's Compensation case management and cost containment studies would be performed with development and implementation of action plans to contain these costs, and completion of supervisor Occupational Safety and Health Act training and general National Electric Code training. This initiative is expected to be completed by the end of FY98.

3. 10 CFR 834 Compliance Effort - ADS# A96D0028: This activity is a two year effort to meet full compliance with this new law. Actions to be completed will include the preparation of an Environmental Radiological Protection Plan and implementation of the actions identified in this plan. This plan is to identify all BNL activities that could result in the release of radio-active materials to the environment, exposures of members of the public to ionizing radiation, or contamination of the environment with radioactive material. BNL has instituted this activity by providing internal funding for a term position to improve the Laboratory's compliance status with the new law when it becomes effective. With this ADS, the implementation plan would be completed by the end of FY97 and implementation of compliance tasks identified in the plan will be completed in FY98.

4. Environmental Planning/Environmental Advocacy Program - ADS# A96D0026: This proposal covers a two year effort to begin in FY97 that will utilize information available in BNL

Environmental Monitoring Plan and Site Environmental Report to develop public environ-mental, safety, and health informational programs. These programs would target BNL operations and develop modules that could be utilized by Laboratory staff and the general public. The information would be used to inform the local public on BNL operations to promote improved trust with the community. These programs are expected to be in-place by the end of FY98.

5. Title V Phase I Permit Application - ADS# A96D0002: This action would complete the preparation of the BNL Title V Phase I Clean Air Act permit application to meet the revisions to 6 New York Code of Rules and Regulations Part 201. This action would identify all air emission source releases and establish a database that would track these releases, compare releases with emission limits to detect possible non-compliances, and general reports needed for annual reporting requirements. The schedule for completion of the permit application process has recently been shortened by the New York State legislature. This process will initiate in FY97 and will be completed by the end of FY98.

6. Title V Phase II Permit Application - ADS# A96D0004: This action would identify and characterize all air emission sources to comply with expected Clean Air Act related regulatory revisions. This information would be collected in a database for use in preparing a site-wide Title V Phase II air permit application that must be submitted in FY00.

Funding profiles can be generated from the ESH Management Plan to profile various Laboratory ESH efforts. Those ESH issues that are presently not addressed as part of the core ESH program are categorized in the ESH Management Plan as compliance or improvement actions. Each of these items has been risked ranked utilizing the current Risk Prioritization Model (RPM) that is part of the ESH Management Plan. Laboratory ESH Management is actively reviewing how other decision factors can be more consistently and formally incorporated into the prioritization process. The RPM, when used alone, is unable to capture the significance of indirect and secondary issues related to ESH. Such issues include, for example, consistency with BNL goals and objectives, efficiency of operations, and activities necessary to promote good standing with the local and regional community and the regula-tory community. While the Laboratory currently uses the "management adjustment" capabilities of the RPM, guidelines are being developed that would standardize these "management adjustments". Addi-tional information on these guidelines are included in the FY96 ESH Management Plan.

The financials needs required to address those items identified as compliance or improvement activities are presented in Table 1. These costs shown as targeted and unfunded to reflect that which is being spent versus that which has been identified but fund allocations to address the action are not available. It is important to note that those issues that receive high RPM scores and adjusted RPM/ management adjustment scores are those issues which receive funding. A review of those presently unfunded issues and their associated RPM scores shows that the Laboratory ESH program is being effective in minimizing ESH risk. Low unfunded values in FY95 through FY97 and low targeted values from FY98 through FY02 reflects movement of unfunded actions to the budget year, FY98, and later. As these items are incorporated into the budget the targeted figures would rise in FY98 and beyond.

TABLE 1
CORRECTIVE ACTION PLAN FUNDING

($ in Millions - BA)	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02
Targeted	5.57	9.30	16.55	3.85	1.27	0.48	0.20	0.14
Unfunded	0.08	0.70	2.20	10.07	6.81	11.98	10.35	11.99
TOTAL FOR LABORATORY	5.65	10.00	18.75	13.92	8.08	12.46	10.55	12.13

Those activities that are considered absolutely essential to the ESH program at the Laboratory are represented in the ESH Management Plan as core functions. Core program functions are all funded. These items are presented in Table 2.

TABLE 2
LABWIDE ENVIRONMENT, SAFETY, AND HEALTH MANAGEMENT FUNDING

($ in Millions - BA)	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02
TOTAL FOR LABORATORY	24.46	26.89	27.76	28.88	30.28	31.07	32.37	33.67

Waste minimization costs funded through EM and targeted are provided in Table 3.

TABLE 3
EM FUNDING

($ in Millions - BA)	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02
Environmental Restoration	13.03	18.40	20.00	20.30	19.90	19.90	19.90	19.90
Total								
Waste Management Operation	6.07	6.00	5.85	5.26	5.26	5.26	5.26	5.26
Waste Management Construction	5.73							
Total								
Pollution Prevention	.18	.04	.60					
TOTAL EM FUNDING25.01	24.44	26.45	25.56	25.16	25.16	25.16	25.16	

The Laboratory has a NEPA Coordinator who is responsible for performing the evaluation of new projects, facilities, and building modifications/additions for potential environmental impacts and for preparing the necessary environmental evaluation documentation. The Laboratory has in place ESH Standard 6.1.1 which defines the NEPA process as well as roles and responsibilities. The BNL Plant Engineering Division, responsible for Design and Construction and General Plant Projects, have their own procedure, D&C 017, for initiating the NEPA process and coordinating projects/activities they manage through the Laboratory NEPA Coordinator. The DOE will not release final funding for projects/activities without completion of the appropriate level of DOE approved NEPA documentation.

E. Environmental Restoration and Waste Management Activities

This ongoing effort encompasses a wide range of activities designed to provide safe and cost-effective management for a variety of radioactive, chemical, medical, or otherwise hazardous wastes generated as a result of past and present operations at the Laboratory. Activities include the following: disposal services (including collection, transport to BNL Hazardous Waste Management (HWM) facilities); sorting; documentation; interim on-site storage, packaging and preparation for off-site disposal; regulatory guidance; quality assurance support; training; and waste minimization assistance.

The BNL HWM Program has the following objectives:

1. To carry out asystematic and definitive planning process which is directed at maximizing efficiency and minimizing fiscal and ESH impact;

2. To provide training for those personnel involved in HWM activities, from generation through disposal;

3. To implement operating procedures and/or process modifications which avoid or minimize the generation of wastes and reduce the hazards of those wastes which are unavoidable; and

4. To provide treatment/storage/disposal facilities which are consistent with applicable environ-mental, safety, and health regulations and which implement requirements including As Low As Reasonably Achievable and Best Management Practices Programs.

Support is provided for both the direct operations of the waste management staff and the Laboratory-generator community. Direct operations include the collection, documentation, storage, limited processing, packaging, transportation, and disposal. Other program elements include planning, quality assurance, regulatory guidance, training, and technical assistance for a Laboratory population in excess of 3,000 persons.

A variety of different quality assurance support services are provided as a part of the BNL Hazardous Waste Program. These include periodic internal and external surveillances and audits, development and implementation of procedures, procurement and receiving reviews, and coordination of the non-conformance reporting system.

The Laboratory continues to develop and implement the HWM Training Plan. This Plan estab-lishes programs to meet federal, DOE, state, and site-specific training requirements, as well as set standards for successful participation in these programs.

These activities are expected to continue through the foreseeable future as long as the types and quantities of hazardous wastes continue to be generated as a result of BNL operations. Projections for the future indicate expanding levels of waste management activity, particularly in light of increasingly stringent regulatory requirements and the inception of waste intensive programs in environmental restoration and decontamination/decommissioning. Counteracting these trends, increasing implemen-tation of the minimization program should help to maintain operational stability.

A contract for construction of new waste management facilities was awarded in March 1995 and construction began in May 1995. Completion of the new Waste Management Facility is expected by the end of FY96 with operation to begin in FY97.

The major program goals for FY97 are:

- Operation of the new waste management facility;
- Investigation of liquid processing options;
- Computer based training for hazardous waste and radioactive waste generators;
- Continue disposal operations within budget constraints; and
- Benchmark/baseline and productivity improvements.

F. Landlord Funded ESH

Through the ESH Management Planning process prescribed by EH, BNL has identified significant ESH risk issues, and proposed activities to resolve/control these issues. Funding to support these issues is partially supplied by Energy Research (landlord). The Laboratory Directorate provides guidance in three specific areas: "landlord" General Plant Project; "landlord" capital equipment; and in a special ESH operating

expense account. This latter expense area is for "one-time" ESH activities requiring overhead operating expense funds. The General Plant Projects funded in this area are for support of sitewide activities. It is the goal of the Laboratory to utilize approximately 20% of the funds received from landlord support for ESH activities. In addition to these funds some Line Item Funding (ER-80) is also provided and is targeted as presented below. Line Item project proposals identified for funding over the plan period include: Sanitary System Upgrade, Phase II; Sanitary System Upgrade, Phase III; Fuel Storage and Transfer Facility Upgrade; Storm and Cooling Water Systems Report/Upgrade; Loss Prevention, Electrical Substations, Phase I; Hot Laboratory Renovation, Building 801, Phase I; Halon Replacement Project; Life Safety Modifications, Phase I; Life Safety Modifications, Phase II; Hot Laboratory Renovation, Building 801, Phase II; Fire Protection Improvements, Phase IV; Fire Protection Improvements, Phase V; Replacement of Site Fire Alarm System; and Fiber Optic Cables, SFAS, Fire/Rescue Group. Additional information on these projects is available in Section IX.A, Facilities' Resource Requirements.

The ESH funding targets from the landlord in FY96 dollars are:

($ in Millions)	FY96	FY97	FY98
General Plant Projects	1.0	1.0	1.0
Capital Equipment	0.2	0.2	0.2
Special ESH Operating	1.28	1.20	1.20
MEL/FS ESH	5.26	11.93	0.57

These amounts are for planning purposes only, and reflect the Laboratory's current understanding of the resources that may be available in these categories. The actual allocations from these sources will depend on the Laboratory's actual authorization.

The maximum funding reduction that could be accommodated by BNL before significant increases in risk within ESH programs would be realized is zero. Several new ESH requirements are being codified by DOE over the next several years that require attention. If these new requirements coincide with a decrement budget reduction, BNL would be required to reevaluate present program and prioritize ESH functions such that some present programs would likely disappear or be maintained in a marginally effective manner. It is impossible to determine which projects would be impacted at this time as it is likely that no one ESH program would be expected to take the full impact of this budget reduction.

The Laboratory has also recently become involved in public controversy stemming from past practices that have resulted in the releases of contaminants to the environment. The public has raised concerns about the operations of BNL and in response to this the Laboratory is endeavoring to develop public outreach programs to assist the general public in understanding the impacts past, present, and future operations will have upon them. These efforts are diverting and will continue to divert resources away from internal ESH programs over the planning period and would enhance the effect of a decrement budget reduction.

G. POLLUTION PREVENTION

As the nation, DOE and the Laboratory move into the future, the environmental emphasis will shift from reacting to today's environmental problem to anticipating and preventing pollution. Within the Environmental Management program, the Laboratory has established goals to minimize the generation of waste during remedial

activities, as well as those wastes generated by normal research and operations activities. Process waste assessments are being conducted throughout the BNL community. These assessments will generate candidate reduction strategies for technical and economic analyses and represent the first step in implementing a Lab wide formal waste reduction program. This activity is conducted under the auspices of the EM-30 program. In addition, the Laboratory has several activities included for funding in the ESH Management Plan which target other areas related to pollution prevention or avoidance. These include activities to implement the Clean Air Act, efforts to characterize and minimize effluent releases from the Laboratory's facilities, upgrades to facilities such as the Sewage Treatment Plant and development of an integrated groundwater management plan and program. Costs attributable to targeted and planned waste minimization activities are presented in Table 4.

TABLE 4
WASTE MINIMIZATION FUNDING

($ in Millions - BA)	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02
Targeted	0.49	0.62	0.38	0.48	0.31	0.05	0.05	0.06
Unfunded	0.05	0.41	0.06	0.09	0.39	1.69	0.06	0.05
TOTAL FOR LABORATORY	0.54	1.03	0.44	0.57	0.70	1.74	0.11	0.11

H. NUCLEAR SAFETY

There are two nuclear reactor facilities at BNL, the High Flux Beam Reactor (HFBR) and the Brookhaven Medical Research Reactor (BMRR).

High Flux Beam Reactor

The Reactor Division (RD) is proceeding with plans to increase reactor power to 60 MW which is now scheduled to occur with the HFBR Upgrade Project. The upgrade includes replacement of the reactor vessel and the cold neutron source, and the addition of a guidehall to house more experimental stations. It is expected that the cold neutron beam intensity will increase by a factor of three and the current number of neutron beam experimental stations will double by providing 15 stations for cold neutrons. Flow reversal testing and analyses which form the bases for safe 60 MW operation were forwarded to DOE for review and approval in December 1995.

Management of spent fuel is critical to continued HFBR operation since the spent fuel canal is nearing capacity. To temporarily address this, a project to increase spent fuel storage capacity of the canal by 162 elements was completed in FY96. Long term solutions including shipping of spent fuel to another DOE facility or further expanding the storage capacity at BNL must be actively pursued. Currently, the BMI-1 cask and the five NAC-LWT casks are licensed for shipment of HFBR fuel. Final arrangements are being made for a shipment of spent fuel to DOE Savannah River Site (DOE-SRS) in FY97. If spent fuel cannot be shipped to DOE-SRS, expansion of on-site wet or dry storage remains an option as an interim measure. In this case, NEPA documentation and conceptual design would be required.

Brookhaven Medical Research Reactor

With the initiation of clinical trials of Boron Neutron Capture Therapy (BNCT) for treatment of malignant brain tumors, the BMRR has entered a new chapter in its history of supporting research for treatment of brain cancer. The initial results of these clinical trials appear favorable, and have generated considerable public interest and pressure to treat more patients.

Final design of a new shutter for the patient treatment beam port has been completed. The shutter will incorporate fission converter plates and a filter for producing an enhanced epithermal neutron beam, with much greater epithermal flux and less contamination by gamma rays and fast neutrons. This will permit a therapeutic radiation dose to be delivered to deep-seated tumors, while sparing normal brain tissue and the scalp. Reduction of the megawatt hours of reactor fuel burnup per patient treatment will be an additional benefit. We expect to begin treatments of patients in a more routine manner within several years. At that time we would hope for funding for this project.

VIII. MANAGEMENT PRACTICES

Brookhaven has had a long history of improving its business and management practices. Its sustained productivity achievements are not the result of a one time, short-term initiatives or simplistic management schemes. It is because of an ongoing and ever changing synthesis between proven techniques, motivation, strong management support and successful implementation. The results are improved efficiency, avoidance and reduction of costs, and improvement in the overall productivity of its staff and facilities.

BNL's program is earmarked by a well developed, continuous budget planning process. This is supported by a policy that limits and controls the size and growth of its overhead functions. The Laboratory exercises a self imposed ceiling on its overhead rate that precludes overhead cost growing at the expense of research. Also, the Director's Overhead Budget Planning and Control Program carefully defines what costs are overhead, outlines the policies for controlling the size of the overhead activities, outlines the cost control and budgeting techniques used by the Laboratory and how its management exercises a powerful control on the hiring process. For example, the Laboratory's Budget Office must approve all requisitions before an employee can be hired at the Laboratory. The Director must approve additions to the indirect cost areas of the Laboratory.

Through normal good management practices, the Laboratory also began a number of new initiatives specifically focusing on deriving support cost savings. These include such activities as a recent requirement that all Laboratory Overhead organizations provide plans by which to achieve self-imposed budget savings. This resulted in a substantial downsizing of many overhead units. The overall goal was to maximize research dollars. At the same time the Laboratory's Cost Control Committee continues on with its activities. Its goal is to evaluate functional elements of all individual Laboratory indirect organizations/activities for need and efficiency, and provide management a basis to determine appropriate sizing, funding levels and charging methodology. The Committee looks at approximately two new overhead organizations a year as well as follow-up on the implementation of its previous recommendations.

BNL has taken an innovative move by creating the "Crazy Ideas" Committee. Employees have been encouraged to submit radical or out-of-the-norm suggestions that could result in potential cost savings or process improvements. The intent was to encourage the infusion of new and innovative ideas or concepts of how the Laboratory fundamentally does business. The committee is currently reviewing these suggestions. The formal process of reviewing a number of Laboratory support operations has also been initiated to determine whether certain functions should be outsourced. This is being performed to meet the requirements of the Make-or-Buy Plan in AUI's Prime Contract with DOE.

In connection with DOEs efforts to have M&O Contractors move away from the "Federal Norm," several Procurement Process Improvement Teams have been established to identify and adopt commercial Best Business Practices. Currently, this covers such areas as consultants, construction, A&E contracts, as well as the overall quality of the procurement process. To further enhance these efforts, Brookhaven has also joined with the Argonne National Laboratory in a cooperative effort on reinvention of the procurement process. A BNL professional staff member is currently a member of the Argonne team.

Two additional committees have recently been established to look for more effective and efficient ways of doing business. A Just-In-Time Committee has been charged with implementing a program for replacing the Laboratory's current Inventory System. A Credit Card Committee is also reviewing the adoptions of credit cards for small purchases $2500 and under.

All of these are just a few recent examples initiated by the Laboratory to achieve savings. A more comprehensive document, the Laboratory's "Cost Mitigation Program," prepared in January, 1995, was formally

submitted to the DOE as part of the negotiations leading up to AUI's new performance based contract. It reviews many of the programs, policies, and techniques which have been or are being used by BNL and AUI to efficiently and effectively manage the Laboratory while also reducing costs.

Finally, the Laboratory has been working with the DOE regarding the subject of "Metrics for Reporting Productivity Improvement." As demonstrated by the following, the Laboratory's efforts have been successful.

	FY92 Costs	FY93 Costs	FY94 Costs	FY95 Costs	FY96 Budget	FY97 Est.	FY98 Est.	FY99 Est.	FY00 Est.
Ratio of Research Labor to Support	1.9:1	2.2:1	2.2:1	2.5:1	2.5:1	2.6:1	2.6:1	2.7:1	2.7:1

Cost Reduction is an ongoing process at BNL. The Laboratory has taken the initiative in the past, and will continue to do so in the future to review its functions with the intent of improving efficiency, avoiding and reducing costs, and improving the overall productivity of the staff and facilities. All of the above, as well as efforts in the Laboratory's Cost Mitigation Program, is ample information to demonstrate that BNL has been continually evaluating its support functions with the intent of reducing costs while still maintaining a highly reputable level of scientific activity. It is believed that BNL is one of the "best-in-class" DOE Laboratories with a strong commitment supporting the Secretary's initiative for cost reduction.

A. SITE AND FACILITIES

1. LABORATORY DESCRIPTION

General

The Laboratory site consists of approximately 2,150 hectares (5,320 acres), and includes over 350 buildings with a gross area of over 349,936 m^2 (3,766,674 ft^2). All Laboratory space is on-site and there is no leased space. Of this area , approximately 209,535 m^2 (2,255,450 ft^2) is classified as research and development use, including the housing of research machines, such as reactors and accelerators; it includes tunnels, experimental halls, utility areas, and support facilities. The remaining building area is classified as either administrative, housing, storage, production, or service use. In addition, the Laboratory has over 225 trailers with an approximate total area of 6,000 m^2 (65,000 ft^2). The Laboratory leases 522 m^2 (5,620 ft^2) which consists of four on-site trailers and one off-site residential apartment. The Laboratory population consists of 3,247 full-time personnel, and a fluctuating roster of guest researchers and other visitors, who come from industry and universities. In addition, consultants, contractors, and special guests also add to the visitor population.

Facility Type	Estimated Replacement (Million $) (per DOE FIMS 3/96)
Buildings	3.268
Utilities	287
All Other Structures	7

Figure A: Facilities Replacement Value (Current Dollars)

Buildings

The Laboratory has brought many of its buildings and facilities up to present-day standards with the help of continuing infrastructure support from DOE. Operational and energy efficiencies were achieved in many areas, and new permanent space was constructed for major scientific departments and research support staff, as funding became available. However, there are many buildings on site whose maintenance and operating costs have steadily increased due to their age. Approximately 246,205 m^2 (2,650,129 ft^2) is over 30-years-old with approximately 131,406 m^2 (1,414,483 ft^2) of that over 40-years-old (Figure C). Based on an assessment of the condition of assets and ability to meet the needs of the program, approximately half of the total space is considered to be adequate (Figure B); the remainder is classified as substandard, of which 60% can economically be made adequate, but the remainder should be replaced (Figure J). To further refine and standardize on the condition of space, BNL is working with DOE to develop a system which will provide a more uniform way of classifying space condition, using condition assessment data. This information then can be entered in the DOE Facility Information Management System (FIMS).

Maintenance and energy costs for the older, wooden buildings are higher than those for structures that are considered permanent. In addition, retrofitting older facilities to comply with ES&H requirements would be extremely costly. Consequently, our planning efforts are directed toward identifying those facilities for which further investment will yield comparable life-extension. Due to the recent structural failure and collapse of Building 424 which was built in 1943 and since used as storage, BNL has begun a multi-phase study to analyze in detail the structural condition of similarly aged wood structures and masonry buildings known to have similar structural deficiencies. This initiative, along with an effort to collect, catalog, and analyze information on building maintenance costs and condition assessment will help to ensure that knowledgeable decisions are made on maintenance and capital investment. This initiative will also identify buildings for which demolition is the best alternative.

Figure B. Condition of Laboratory Space

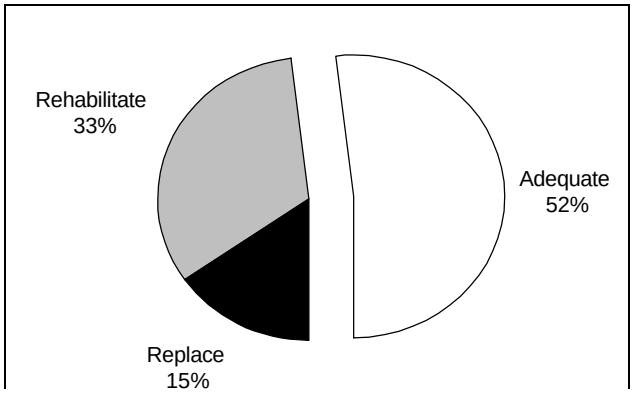
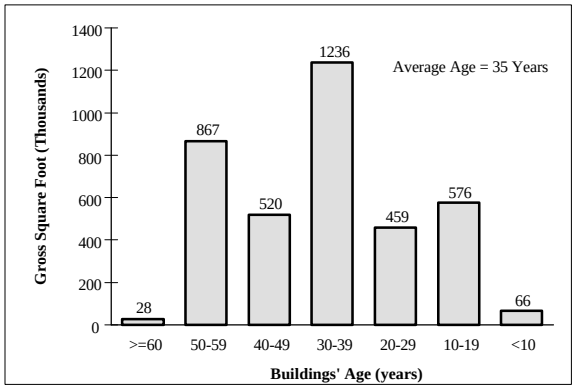


Figure C. Age of Laboratory Buildings



The presence of asbestos-containing materials and lead painted surfaces in existing buildings and structures can negatively impact the scope, cost, and schedule of construction if not completely identified in the project's planning phase. These issues continue to impede the progress of construction as they can not always be completely identified and characterized until some work is accomplished. When asbestos or lead is suspected, construction is suspended while samples are taken and the hazard is abated. Strict administrative controls, increased labor, and additional costs are routinely required to prevent occupational exposures. The Laboratory has prepared a Conceptual Design Report (CDR) which identifies specific needs for the abatement of known areas containing asbestos. Line item funding is not planned for until some time after FY 2002, based on current higher priorities.

Approximately 176,000 m^2 (1,900,000 ft^2) of roof area was surveyed in 1989 to determine the extent of repairs and replacement required. The report concluded that over half of the area was in "poor" to "failed" condition, and needs replacing. Many roofs have long exceeded their useful life and are becoming an operational burden with the potential for loss of equipment and experimental data from water damage. These risks were validated by a DOE ES&H assessment. The recent FY 93 Line-Item project replaced approximately 24,500 m^2 (263,00 ft^2) of roofing in 17 buildings. However, the increasing costs associated with annual maintenance further emphasizes the need to take steps toward replacing the remaining roofs identified in the study, or those which have since further degraded to the point of needing replacement. According to DOE directions, continuation of the roof-replacement program must come from operating funds. As these budgets are also quite constrained, this will only increase the costs to operations, delay the needed work, and ultimately, be more costly due to the smaller project size and protracted schedules. A BNL team was formed to begin planning the update of the 1988 Roofing Study and continue BNL's program of roof replacement using only operating expense funding.

Warehousing

Operationally, there is a need to unify and consolidate warehouse functions to improve efficiency. Of even greater concern are the results of past condition assessments. These 1940s vintage wood-frame warehouses were built to Army standards for temporary facilities, and have increased potential for structural problems due to their age and deterioration. These factors, coupled with the recent structural failure of a similar building, prompted BNL to initiate a more in-depth review of these facilities for structural deficiencies. Labor hours and energy inefficiencies associated with these buildings increase the Laboratory's operating costs. Due to the nature of research at BNL, there is a need to receive, warehouse and distribute large volumes of a wide-range solvents, degreasers, and oils which are often toxic and hazardous to the environment. These materials currently are stored in several different warehouse buildings that were not originally designed to prevent intrusion into the aquifer if there was an accident. In addition, operational efficiencies and stacking options are greatly restricted by allowable floor loading, ceiling heights, and the location of existing building columns. Building configurations are inappropriate for efficient use as warehouse space. A program is needed for replacing the existing wooden warehouses. Requested funding will provide for a modern, energy-efficient warehouse, which incorporate current material-handling techniques.

Utilities

DOE's support for improving utilities and infrastructure has enabled the Laboratory to maintain its utility systems in relatively good condition. Major improvements continue and are planned in many areas, including potable water, sanitary sewage, chilled water, steam, and electric power distribution.

The electrical supply and distribution systems are being reinforced to accommodate growing demand. This growth affects two areas; the electrical power transmission supply from the regional utility, the Long Island Lighting Company (LILCO), and the internal medium voltage (69 kV & 13.8 kV) distribution systems. BNL load forecast projects that the current 62 MVA peak load will grow to 134 MVA by FY 2010 due to various new initiatives including those relating to the Relativistic Heavy Ion Collider (RHIC), High Flux Beam Reactor (HFBR) upgrades, and Magnetic Resonance Imiging (MRI) Facility . In response, one of the two transmission supply lines recently was upgraded from 69 MVA to 143 MVA. Additionally, BNL is studying several ways to cost-effectively address reliability concerns, which include power-factor correction, reconfiguration of loads, and additional and larger transmission and distribution supply feeders. Analysis of potential solutions is made more complex by the nature of BNL's loads, many of which are pulsating and require careful review for compatibility with internal BNL loads and the requirements of LILCO's external supply system. It is anticipated that this study will identify future projects to meet forecasted requirements and increase the system's reliability and availability.

Two main (69 kV - 13.8 kV) substation transformers have been in service for nearly 30 years. However, one unit is currently being replaced (Figure E). Substation transformers (69 kV - 13.8 kV) and primary distribution transformers (2.4 kV, 480 V, and 208 V secondaries) are being carefully monitored to detect and predict failures due to age-induced breakdown of insulating materials. In the electrical distribution system, we have experienced periodic failures of underground cables. The condition of the electrical ductbank system, conveying these cables, has deteriorated in several locations and some ductbanks have collapsed. Twenty 13.8 kVA feeder cables have been in service over 30 years, eleven of which are over 40-years-old (Figure D). Most feeders over thirty years old need replacing within the next ten years. BNL is planning to build new "loop-arranged" feeders to address the feeders' expected life and improve the systems' reliability and availability.

Trichloroethane (1,1,1) contamination was discovered in some potable water wells on site. Three of them, which directly supply the potable-water distribution system, were fitted with carbon adsorption filters to remove contaminants. Three other wells, which discharge to the central-water treatment plant are currently being fitted with air strippers to remove the contaminants (Figure F). Of the three remaining wells, all of which are out of

service, two are beyond economic repair, are no longer needed, and will be permanently closed. The remaining well, No. 2, may be re-drilled and returned to service.

In the potable-water distribution system, corroded and tuberculated cast-iron piping, transite pipe which is very susceptible to breaks, and piping with lead connections will need to be replaced (Figure G). Two projects were identified to deal with this problem. One is under construction, and line-item funding for the other is anticipated in the early FY 2000s. As part of ensuring State Pollutant Discharge Elimination System (SPDES) compliance, BNL is currently monitoring iron discharges at the Water Treatment Plant, produced from backwash operations. Depending on the outcome and subsequent discussions with State officials, a collection system for these discharges may be considered.

BNL's sanitary system consists of over 50 km (31 miles) of collection piping, much of it dating back to World War II (Figure H). Video surveys of 14 km (47,000 ft.) showed that some pipes have open joints, leaks, root intrusion, and other defects. These leaks are a potential source of groundwater contamination. BNL Waste Water Treatment Facility (WWTF) provides primary treatment for up to 2.3 million gallons/day. The WWTF is regulated by a SPDES permit issued by the New York State Department of Environmental Conservation (NYSDEC). The WWTF has been the focus of increasing community-stakeholder concerns and related adverse press-coverage. The concerns center on the WWTF discharges to the headwaters of the Peconic River, which is designated a state wild and scenic river, and is part of the Peconic Estuary.

BNL has embarked on a program to upgrade the collection system and WWTF to protect the sole source aquifer, ensure SPDES compliance, and address the stakeholders' concerns. The Sanitary Upgrade Phase I project, currently underway, upgrades the WWTF to secondary (biological) treatment and replaces approximately 1.1 km (3,500 ft.) of major trunk piping between the site and the WWTF. (Note: public concerns over construction de-watering have significantly delayed this project.) For the Sanitary Upgrade Phase II project, started in FY 1995, 1.1 km (3,500 ft.) of major trunk piping already was replaced. The remainder of the project is on hold awaiting DOE approval of a request to reprogram the funds for further plant upgrades.

At this writing, BNL and DOE are discussing reprogramming Phase II funds to incorporate tertiary treatment (nitrogen removal) and UV disinfection (eliminates chlorine discharges and controls coliform bacteria) into the current WWTF upgrades. If approved, this reprogramming will accelerate future planned upgrades to address the major concerns of the stakeholders. Piping replacements and repairs will be postponed to the proposed Sanitary Upgrade Phase III. This project, proposed for FY 1999 funding, will continue the prioritized replacement of additional, deteriorated collection-system piping. (The final scope of the Phase III project is contingent on whether DOE approves the proposed reprogramming.)

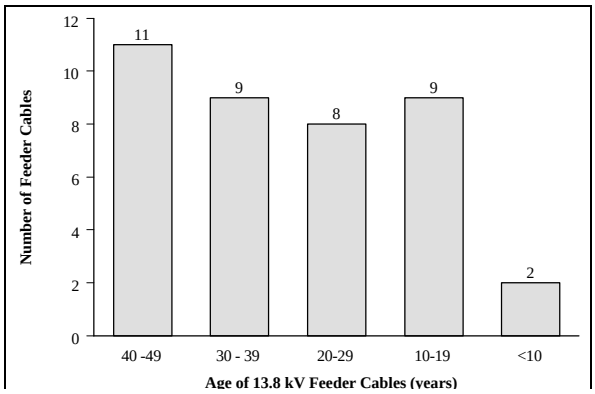
BNL's wastewater discharge permit (SPDES) mandates a reduction of dilution water in the WWTF influent. The proposed Storm and Cooling Water Upgrades project was developed to correct this problem. This project will upgrade on-site storm drainage systems and significantly reduce once-through cooling water discharges to the sanitary waste-water system, thus reducing the dilution of the sanitary waste. This reduction in cooling water will help improve the WWTF performance and assure that BNL complies with the requirements of its SPDES permit. Additional recharge areas are being planned, funded by EM-40, to support Environmental Restoration efforts; these include two groundwater cleanup plants and a stormwater recharge basin for the former landfill. Modification to the SPDES permit will be integrated into the projects.

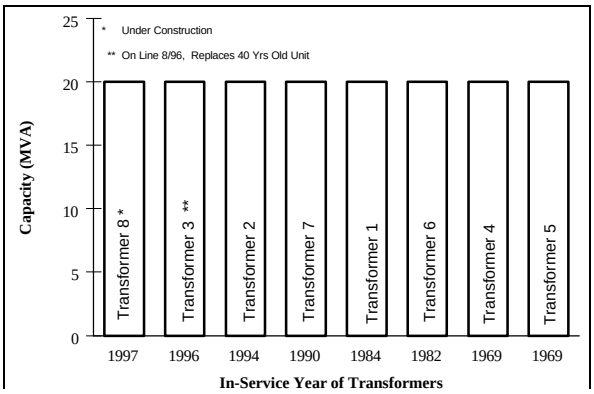
The Central Steam Plant consists of two oil-fired boilers in service more than 30 years, one boiler in service 10 years, and one new boiler which will go on-line this year (Figure I). Current plans are to study extending the life for BNL's largest boiler, No. 5, with preliminary plans for possible retubing. An additional area for study is the impact of the lower NO_x emission standards in Phase II of the Clean Air Act, scheduled to take effect around the year 2000. BNL anticipates that if it is successful in converting the boilers to dual-fuel capability (see *Energy*

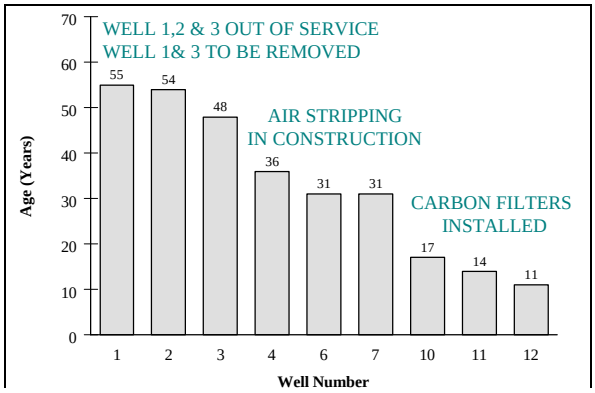
below) that the impact of the new regulations will be much less than on the current oil-fired boilers. BNL fuel-oil transfer facility is currently being modified by adding spill containment and a pump house to meet state environmental requirements. BNL is planning to study the underground steam-supply piping to determine the condition and life expectancy of the various sections. Over the long-range, BNL anticipates that some older sections will warrant replacement, based on their assessed condition and energy inefficiencies due to leaks.

The current Energy Management System (EMCS) and Site Fire Alarm Systems (SFAS) use networks consisting of hard-wire underground phone lines. Most of this wire was installed 15 to 30 years ago does not meet current specifications for reliable high-speed millivolt digital transmission. Within the SFAS alone, there are over 400,000 connections, most of which are in underground manholes prone to moisture and corrosion. These connections are failing, interrupting the system and increasing maintenance costs. In addition, existing central plants must be monitored separately as they can not be networked due to the technical limitations of the current wiring. BNL will be initiating a study to modernize the system using existing and new fiber-optic cables. The study will consider EMCS, SFAS, security and plant controls, and seek to maximize cost-effectiveness while achieving the needed technical performance.

The ductbank system which supports the Laboratory's communication systems needs significant repair and replacement. Many sections are full, or are impassible due to collapsed ducts. This significantly impedes the implementation of smaller projects which must now either route cable through longer routes or bear the burden of installing conduit in parallel with full duckbanks. While the new digital telephone system, placed in service this year, will enable new data-transmission capabilities to be installed, additional high-speed fiber cables, and the means to route them to BNL buildings, will be needed to meet future networking demands.







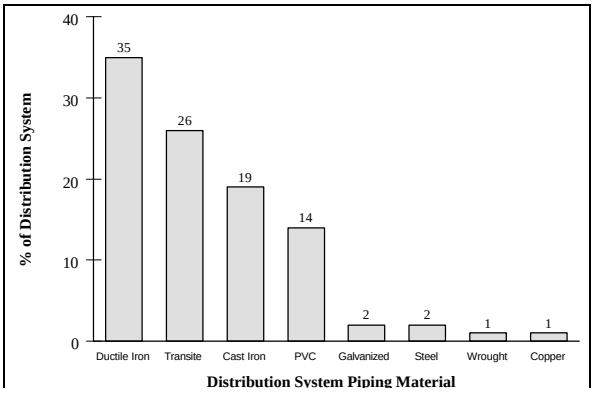


Figure D: Electrical Distribution System - 13.8 kV Feeder Cables

Figure E: Electrical Distribution System - Substation Transf. 69 kV - 13.8 kV

Figure F: Potable Water System - Individual Wells

Figure G: Potable Water Distribution System - Piping Material

Figure H: Sanitary Piping System - Inspected Piping

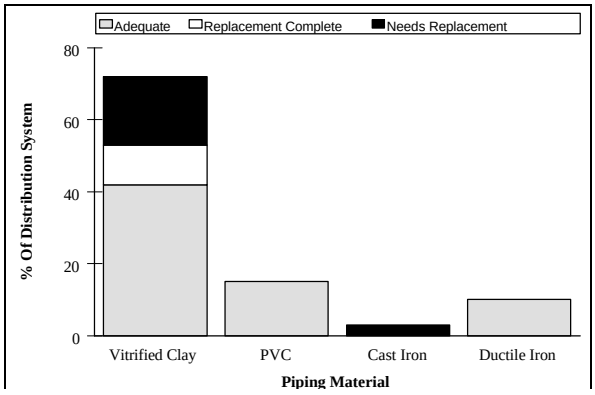
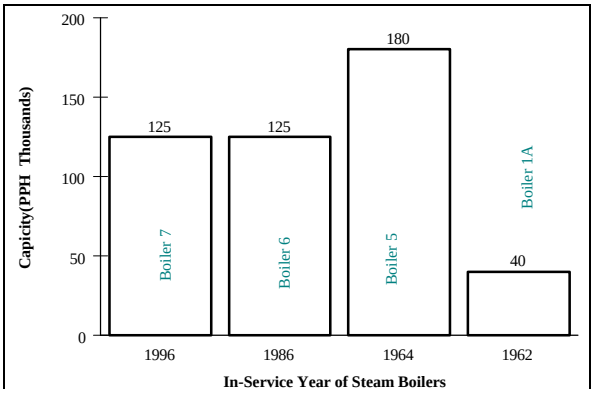


Figure I: Central Steam Plant - Boiler Capacity & Age



Multi-Program Facilities

Several line-item projects dealt with the need to provide adequate space in multi-program facilities for BNL research programs. In FY 88, the Biology Building was rehabilitated and, in FY 95 an addition was approved for Building 815 to consolidate the Department of Applied Science groups. BNL will continue the effort to evaluate Condition Assessment data for its permanent multi-program facilities and will propose line-item projects to address deficiencies and bring the facilities up to current standards.

Support Facilities

Various assessments identified the need for new support facilities; these include a new Police Headquarters, Visitors Reception Center, Central Training Facility, and Emergency Operations Center. These proposals have several common drivers which include the poor condition of existing facilities and inefficiencies in current operations due to the location and configuration of the facilities. Additionally, there is a need to consolidate certain support divisions to maximize efficiencies and reduce associated costs as far as possible. In the next few years, BNL will investigate these issues and develop strategies to address the concerns they present. Probably BNL will ultimately propose projects that combine these requirements into facilities which will accommodate multiple needs.

In addition, the Plant Engineering Division, whose shops, engineering, construction, and administration groups are housed in separate facilities, is currently working on a Strategic Plan to identify ways to better align the organization to be more cost-effective. It is anticipated that area shops will be created to better serve customers' requirements and that the remaining core operation will be consolidated. This consolidation will likely lead to a request for a new facility to better house core operations. Most of the facilities which would be vacated are beyond economic repair, and would be slated for demolition.

Energy

DOE has been very supportive of the Laboratory's Energy Management Program, and many energy saving projects have come to fruition. Installing a site-wide Energy Management Control System (EMCS) assisted the Laboratory in achieving its energy conservation goals. The current Chilled Water Thermal Storage project will provide 253,000 MJ (20,000 ton-hrs) of stored cooling energy and reduce BNL's peak demand by 2-3 MW.

The Laboratory currently is converting the Central Steam Facility to dual fuel capability. BNL is working to bring natural gas onto the site by FY97, provided by LILCO, whose gas main runs past the south side of the site. LILCO has made a proposal to supply interruptible gas service to the site, at an attractive rate, through 2001.

As the RHIC project nears completion, more detailed analyses have been made of the electrical power requirements. To help meet these requirements, BNL has reached an agreement-in-principle with the New York Power Authority (NYPA) for an additional 35 MW of low-cost power. This power will be phased in over the next several years. The final contract is being reviewed by DOE.

Cogeneration

The Laboratory continues to monitor the economic environment for cogeneration on Long Island. At present, there is an excess of electrical-power capacity in New York State, and unattractive sell-back rates. This, coupled with BNL's load profile and the availability of relatively low-cost electricity from the New York Power Authority, presently make cogeneration economically non-viable.

Space

The Laboratory's 350 plus buildings are diversified and include various facilities and space dedicated to the programmatic effort, such as accelerator tunnels, reactor facilities, experimental halls, one-of-a-kind research facilities, offices, laboratories, and warehouses. Through its space- management initiatives, the Laboratory has effectively used its available space, thus avoiding unnecessary construction. However, due to inherent inefficiencies in layout, it is often necessary to split some organizations which require less contiguous space into smaller groups, loosing overall organizational effectiveness. In addition, many of the Laboratory's support divisions are currently housed in World War II facilities. The Laboratory has identified several line-item projects for consolidating scientific departments, including the Departments of Applied Science and Advanced Technology. New facilities are proposed for these consolidations.

To more effectively manage BNL's space, several reforms are being instituted, including a space charging program and new space-management policies. The space-charging program will more accurately document the use of space in all buildings. This effort already has yielded more precise data for incorporating into DOE's Facility Information Management System (FIMS), as well as provided new tools for Infrastructure Management personnel to manage, plan, and forecast space requirements. By charging for use of space, BNL anticipates that there will be a site-wide incentive to use space in the most efficient manner. This will result in realignment of space to increase efficiency of operation, and allow for consolidation and possible reduction in maintenance through mothballing or the elimination of unneeded space.

ASSET	CONDITION OF SPACE (SQUARE FEET)						
	ACTIVE FACILITIES			SURPLUS FACILITIES			
	ADEQUATE	REPLACE* Substandard-Cannot Make Adequate	REHAB Substandard-Can Make Adequate	ADEQUATE	REPLACE* Substandard-Cannot Make Adequate	REHAB Substandard-Can Make Adequate	TOTAL
Administrative	420,249	228,030	166,200	0	0	0	814,479
Housing	72,104	5,362	133,634	0	0	0	211,100
Storage	38,000	154,600	20,100	0	1,600	0	214,300
Production	13,000	1,300	1,300	0	20,130	0	35,730
Service	30,050	113,425	111,250	0	600	0	255,325
R&D	1,366,666	71,300	797,774	0	0	0	2,235,740
Total	1,940,069	574,017	1,230,258	0	22,330	0	3,766,674

***** Needs to be replaced within the Master Plan period (20 years

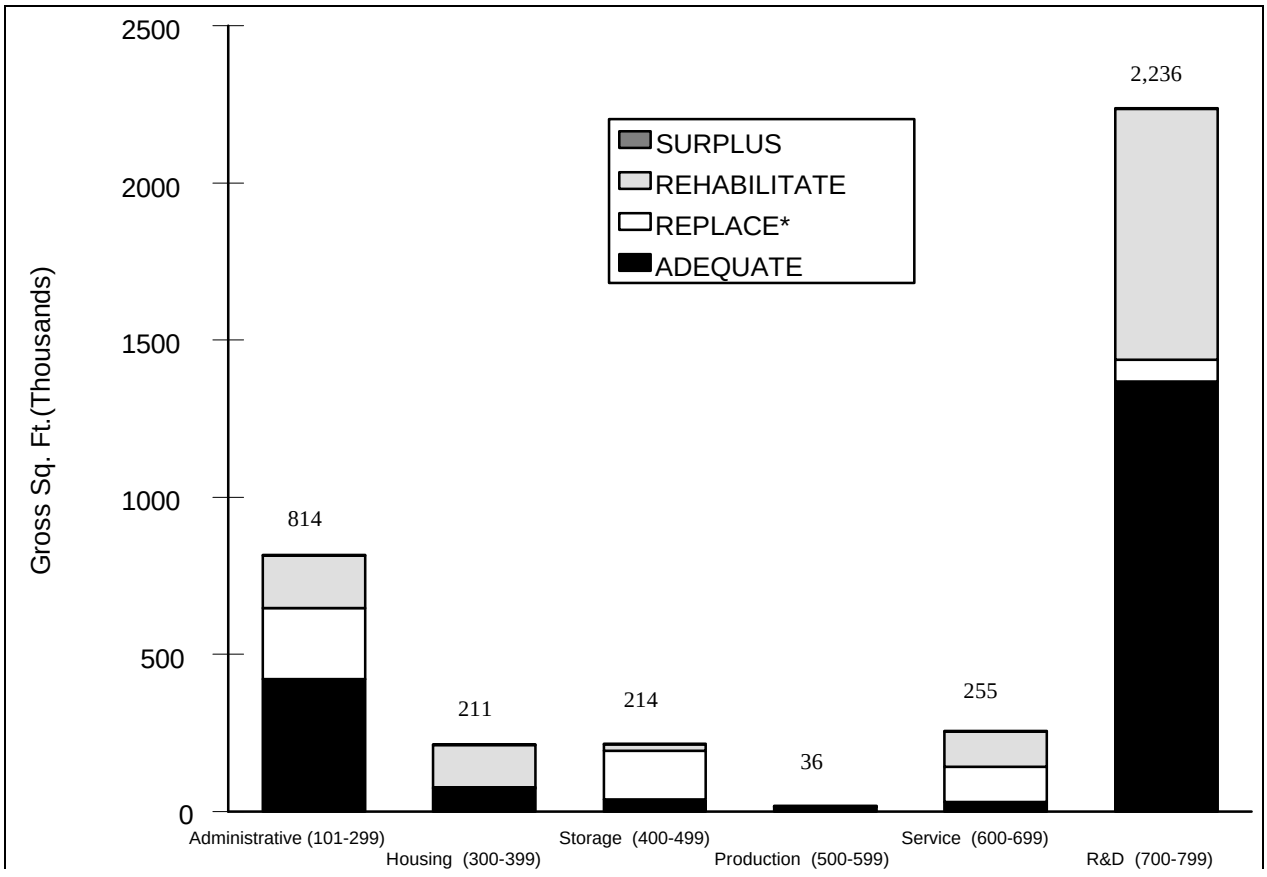


Figure J: Use and Condition of Space

2. FACILITIES PLANS AND OPTIONS

Evolution of the site from Camp Upton, a military facility of 1940's vintage, into a major scientific research facility has been, and continues to be, an extremely challenging undertaking. It is important to know that the original strategy for developing the Laboratory included the following concepts:

- To use existing buildings as long as possible to permit a multi-disciplinary research program to grow as rapidly as possible.

- To retain the general pattern of the former Army camp's site for economic reasons, and because it seemed consistent with foreseeable developments.

- To locate major research machines immediately north of the existing built-up central area where the natural contours and undeveloped lands were most suited to their special requirements.

This strategy served the Laboratory well, and deferred the spending of millions of capital dollars through the years. New buildings were initially added with restraint, and were constructed as the Laboratory established itself as a premier research institution, additional permanent structures such as the Chemistry, Physics, Biology, and Medical buildings.

The completion of the Laboratory's newest research tool, the Relativistic Heavy Ion Collider (RHIC), will provide new capabilities to produce and study new phases of matter. The decade of the 1990s was, and is, a time for change, not only in Strategic Planning, but also in the need for sophisticated facilities management and prioritization of needs. While the original strategies established the Laboratory, new strategies must now meet the challenges of maintaining old deteriorated wood- frame structures and aged utility systems in a period of declining budgets. To meet these challenges, new strategies continue to be developed, some of which are as follows:

- Form Planning Teams, composed of engineers and craft supervisors, to identify issues related building and utilities. These issues then are communicated to management, along with proposed actions to identify capital and operating funded projects and their potential impacts.

- Implement a space- charge program, with the goal of providing further incentive for consolidation. This will potentially free-up space for continued use, or allow space that is no longer economical to maintain to be demolished or mothballed.

- Make structures more energy-efficient, attractive, and lower maintenance costs through replacing windows and doors, and adding insulated siding.

- Develop plans to further consolidate personnel by enhancing the space management program. This will allow those wood structures, where the condition does not warrant further maintenance or capital investment, to be vacated and either mothballed or demolished.

- Analyze make-or-buy options for Laboratory support operations and adjust them to reflect the most cost-effective solutions.

- Continue to ensure that funding provides the maximum benefit by continually improving and expanding project prioritization schemes. Recently, the system to prioritize large maintenance projects was formalized to ensure that the greatest needs are being met consistently.

As new programmatic initiatives are completed over the next five years, the Laboratory will experience a large influx of users, collaborators, and visitors, creating an increased demand for work space, and support services. This will be offset, but only in part, by reductions in program and support staff due to budget reductions and overhead cost cutting initiatives. Several projects proposed in this plan address the need to further consolidate major scientific departments and support functions currently dispersed throughout the site.

3. GENERAL PURPOSE FACILITIES PLANS

General Purpose Facilities are those which can be used by more than one DOE program. As a result of the process through which the Laboratory developed, often it is difficult to readily distinguish facilities as belonging to single departmental users; this is further complicated as some programs involve multiple departments. Many buildings and Laboratory facilities are shared by two or more departments, and it has long been the Laboratory's objective to establish individual core-centered departmental complexes. This objective continues to be a high priority. BNL instituted the DOE Condition Assessment Survey (CAS) program and modified it to meet its needs as a key to its planning efforts. Another key element which incorporates all functions of the asset planning process is BNL's facilities planning process. This process coordinates functions including Site Development Planning, Condition Assessment Surveys, Institutional Planning, Future Land Use Planning, and capital construction project planning. The evolution of this process will be comprehensive facilities planning as described in the DOE Life-Cycle Asset Management (LCAM) Order, in which BNL will work with the DOE Brookhaven Group in refining the process to ensure it meets the needs of its internal customers (BNL departments and divisions), external customers (DOE), and community stakeholders.

Recent changes in BNL accounting methods, to bring the Laboratory's system into alignment with Cost Accounting Standards (CAS), now require the Laboratory's indirect costs be applied to all capital construction projects including line-items, GPP, ARAM, and AIP. This action has effectively reduced these programs by 12% during a period marked by static funding levels which do not reflect inflation.

Multiprogram Energy Laboratory/ Facility Support (MEL/FS) Program

Over the past decade, the MEL/FS Program provided vital support to BNL's infrastructure. Central utility plants producing steam and potable water were renewed and expanded, and a facility for chilled water and compressed-air with associated underground distribution systems was constructed. Other utility lines and equipment were replaced or expanded. Fire protection and detection systems were added to many Laboratory facilities, and a new fire station was constructed. In addition, one project relating to efforts to consolidate departmental groups has been funded.

The BNL goals for this program are to upgrade environmental safety and health (ES&H) protection, improve site utility systems, increase the staff's efficiency through consolidation, and also to replace, mothball or demolish aged inefficient facilities to reduce operating costs.

Inadequate funding for the General Purpose Facilities sub-program is continuing the cycle of having high operating and maintenance costs, rather than having prudent reductions in life-cycle costs through increased investment in new facilities. The Laboratory is concerned about the ability of the MEL/FS Program to address these projects and ES&H projects, while dealing with issues of core infrastructure.

The anticipated/expected MEL/FS Line Item requirements from FY 1997 to FY 2002 is approximately $ 62.1 Million (Figure K). Based on a ten-year average funding level of $5.5 Million, a $ 44 Million shortfall is expected.

In summary, the low funding levels, which current DOE guidance is suggesting, will challenge the Laboratory's ability to improve infrastructure. At the same time, operating costs certainly will increase as the maintenance of various aged buildings and utility systems becomes more difficult. The consolidation of staff, both in the scientific and support areas, will continue to be delayed, and the thrust of future initiatives will be affected by the Laboratory's ability to provide a working environment consistent with the quality personnel it must attract.

PROJECT TYPE	FY 98	FY 99	FY 00	FY 01	FY 02	TOTAL
ES&H Support	0.6	2.0	9.1	9.5	9.4	30.6
Building Rehabilitation	0	0	0	0	0	0
Utility Rehabilitation	1.2	4.5	1.0	4.0	4.0	14.7
Roads/OSF Rehab.	0	0	0	0	0	0
New/Replacement Bldg.	0.9	6.8	4.2	0.5	4.4	16.8
TOTAL	2.7	13.3	14.3	14.0	17.8	62.1

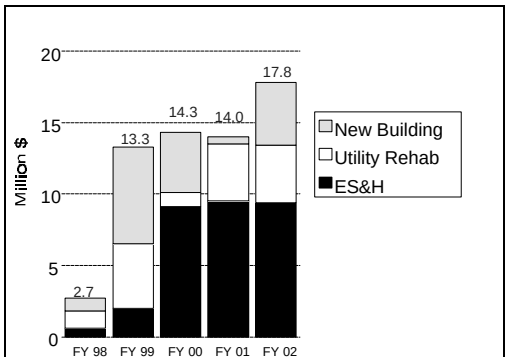


Figure K: Line Item Funding Requirements ($M) - By category and by year (GPF Only)

General Plant Projects (GPP)

GPP has been, and will continue to be, the mechanism for addressing short-term construction needs. Historically, DOE's emphasis on ES&H and Security requirements have generated major immediate needs which required significant levels of GPP funding of approximately 20% of GPP funding. GPP projects are the result of developing requirements for research support, and continuing study of the adequacy of plant facilities and utilities. The Laboratory annually updates its list of expected GPP requirements by conducting an internal GPP Budget Call to its departments and divisions. During the past five years, the shortfall has remained level at $27 Million, with the funding level averaging $5.7 Million.

From a review of the trends in funding and the level of new anticipated requirements, the cumulative shortfall in GPP funds will increase. This projection also is supported by the large shortfall in infrastructure projects which cannot be delayed if the Laboratory is to meet urgent goals and the expected needs which will be identified by BNL's building and utility planning teams. Additional requirements are being generated by the systematic assessment of assets through condition assessment surveys which will support analysis of facility-(asset) level life-

cycle plans. As noted earlier, these opposing trends will require a more sophisticated planning and project prioritization to focus limited resources on the very highest priority projects and maximize the availability and reliability of building and utility infrastructure. Part of this process will include the Infrastructure Management Plan, if implemented by DOE. This process is currently under development by DOE.

General Purpose Equipment (GPE)

General Purpose Equipment (GPE) covers the requirements for equipment which have no specific program application. This equipment is essential to maintain the day-to-day operation of the Laboratory, as well as covering the needs of Environmental, Safety, Health, and Security. This list includes equipment for the Laboratory's technical service groups, Computing and Communications Division, Automotive, Heavy Equipment, Financial Services, Administrative Support, Central Shops, and other miscellaneous areas.

GPE funding traditionally has been 50% of the needed level, forcing the Laboratory to prioritize its urgent needs and to postpone many justified requests. This practice also forces the continued use of outdated equipment with its associated high maintenance costs and losses in productivity. GPE projects are the result of developing requirements to provide general support to the research programs and Laboratory operations, and the continuing study of the adequacy of plant facilities and utility systems. The cumulative estimated shortfall in funding is $5 Million.

Maintenance

Maintenance service at BNL is provided by building trade crafts and general labor crafts, for non-Davis Bacon covered work. These activities include operating and maintaining the site utility plants including the Central Steam Facility, Water Treatment Facility, Sewage Treatment Facility, Central Chilled Water Facility, and Electrical Distribution System, as well as providing mechanical, electrical, and building trade services for more than 350 buildings on site. General labor personnel handle custodial services and grounds maintenance. Non-programmatic, real property maintenance is coordinated by the Maintenance Management Center, responsible for work-order management, planning and estimating, preventive and predictive maintenance, and facility inspections that identify larger projects for future maintenance-project funding.

The developed portion of the site has been increasing at a time when overhead costs have had to be reduced, based on emphasis placed by both DOE and BNL. These factors have caused maintenance funding to be increasingly constrained and has increased competition for such funds. These pressures tend to keep our maintenance efforts at a functional minimum. New strategies are being explored to provide more cost-effective maintenance; they will be defined in the Plant Engineering Strategic Plan which is under development. Opportunities for consolidation are expected as a result of the recent policy to charge for use of space. In addition, use of In-House Energy Management (IHEM) program funds has helped to make buildings more energy efficient and reduce operating costs. BNL hopes Congress will reinstate the IHEM program. Better methods for project prioritization have been developed and are being applied to the larger maintenance projects to ensure that the limited funds are used to mitigate the highest operational risks.

4. INACTIVE SURPLUS FACILITIES PLAN

The Laboratory previously identified its strategically required facilities by analyzing its existing programs, planned activities, and physical assessment of existing assets. After subsequent reviews buildings were placed into five general groupings (in accordance with DOE Surplus Facilities Inventory Assessment (SFIA) procedures). The outcome was originally documented in BNL's 1994 Integrated Facilities Plan and subsequent updates were made to the SFIA database. Four facilities identified as surplus (Buildings 195, 196, 526B and 529) were demolished in FY94 and FY95 with KG-03 funds. The SFIA identified eight surplus facilities which could be transferred to EM and three facilities for removal with ER program funds.

Building 428, an old incinerator constructed in 1943 and decommissioned for over twenty years, is slated for demolition, pending program funding. Some funding originally provided for this task was reprogrammed to remove Building 424 which collapsed from structural failure in the Blizzard of 1996. Additional funding has been requested to demolish Buildings 93 and 168, the enclosures for Wells 1 & 2, which were decommissioned approximately 10 years ago. The following table summarizes facilities requested for demolition either through the landlord program (ER) or transfer to EM.

BUILDING NAME	FIMS ASSET #	DOE SPONSOR	PROGRAM FOR DEMOLITION $
Well #1	0093	None	ER
Well #2	0168	None	ER
Incinerator	0428	None	ER
Chemical Storage	0444	EM-30	EM
Administration	0445	EM-30	EM
Waste Compaction	0446	EM-30	EM
Storage Rigging	0447	EM-30	EM
Nuclear Waste Storage	0448	EM-30	EM
Hot Laundry/Reclamation Fac.	0650	None	ER
Radioactive Storage	0650A	None	ER
BGRR	0702	None	EM
Instrument House	0708	None	EM
Canal House	0709	None	EM
Gamma Pool	0830 (Partial)	None	ER
Former 7' Bubble Chamber	0960	None	ER

5. ASSETS MANAGEMENT

The Laboratory maintains comprehensive Assets Management Programs that encompasses all of the elements necessary to utilize, control and dispose of its assets in a cost effective and efficient manner. Asset management is divided into twp general categories, real property and personal property.

Real Property

Real property records are maintained in the DOE Facility Information Management System (FIMS) and reconciled with the Laboratory's financial records. As part of the Facility Inspection Program, FIMS records and building key plans are reviewed during field surveys to ensure the records are accurate. Building condition information, deficiency lists, and requested upgrades are reviewed to determine facility life-cycle plans and identify those assets for which further capital investment is warranted or for which demolition is the best plan. For those assets which the Laboratory seeks to demolish either DOE ER-7 landlord funds or DOE EM funds (those assets meeting the SFIA criteria for Group 1) are requested.

Personal Property

The Laboratory utilizes an active Walk-Through Program which ensures that every major facility is reviewed on a scheduled basis to monitor and identify any idle or surplus materials. In addition, the Laboratory also utilizes a site inspection program which monitors the accumulation of materials. These programs, coupled with the Waste Minimization Program provides the Laboratory with the ability to dispose of surplus assets in a timely, efficient manner, consistent with the appropriate Federal Property Management Regulations.

6. FACILITIES RESOURCE REQUIREMENTS

The facilities issues which have been discussed will strain the current sources of funds. The Multiprogram Energy Laboratories/Facilities Support (MEL/FS) and General Plant Projects (GPP) programs have been called upon increasingly to meet special requirements, such as security, safety, and environmental problems, without a corresponding increase in funding. Since these needs are frequently regulatory-based, these projects often rise to top priority at the expense of mission and infrastructure support projects, which are vital to maintaining long-term condition and serviceability of the physical plant. In addition, the relatively level funding over the past several years, now coupled with additional indirect costs being placed on capital construction, has meant that the actual realized funding level has declined significantly.

In response to the programmatic, building, and utility needs and proposed initiatives outlined in this document, BNL developed specific projects, as described below in further detail:

1. *Programmatic Construction Projects*

These program projects are being submitted in support of programmatic initiatives for consideration of programmatic capital funds.

National Synchrotron Light Source Phase III Upgrade (FY 1999)

In addition to machine and beamline upgrades which will improve beam intensity and stability, this project will provide a 875 m^2 (9400 ft^2) second floor addition over the X6 - X16 beamline region. This addition will contain 12 offices, a conference room, and a open landscape area for development into user space. A utility isolation system for electrical power quality and a new insertion device also will be provided.

Hot Laboratory Addition for PET (FY 1999)

This project will add approximately 350 m^2 (3,800 ft^2) of new laboratory space to the cyclotron building, Bldg. 901. This space will be used for radiotracer research and for the routine production of radiopharmaceuticals for PET. The facility will contain shielded synthesis cells, a laboratory for robotics and automation, and laboratories for biological studies and for analytical and quality control of radiopharmaceutical preparations for human studies. This new space will replace an existing, deteriorating laboratory space which has marginal emergency/safety exits and ventilation, and inadequate workspace and utilities for the 15 scientists and technicians who use it daily. In addition, the proximity of the added laboratory space to the cyclotrons will minimize the distance for transferring radioisotopes between them. Additional office space also will be provided.

Life Sciences Support Facility Addition (FY 1999)

The addition of approximately 3,700 m^2 (40,000 ft^2) of laboratories, offices, and conference facilities will integrate the current activities of the Biology Department and the Protein Data Bank under one roof, accommodate continued expansion of programs in human genome sequencing and structural biology, provide suitable facilities for training and technology-transfer programs, and enable the the National Resource Center for Biotechnology to be established.

NSLS DUV-FEL Facility (FY 2000)

The purpose of the Deep Ultra Violet Free Electron Laser (DUV-FEL) project is to construct and operate the foremost source of intense ultra-violet radiation for applications of programmatic importance to the DOE. The DUV-FEL represents a qualitative advance in the capabilities in this spectral region. As presently conceived, the DUV-FEL facility would be the premier research tool for applications in the vacuum ultra-violet region. This project will construct a fourth generation light source in the VUV and beyond. The project plans to make extensive use of existing equipment that was previously procured/fabricated for the Defense Advanced Research Projects Agency (DARPA). This project will construct two additions to existing Building 729; a 216 m^2 (2325 ft^2) addition to the west, and a 300 m^2 (3225 ft^2) addition to the east. Some modifications to Building 728M and additional utilities also will be required.

High Flux Beam Reactor Upgrade Project (FY 1998)

This project will provide upgrades to the BNL High Flux Beam Reactor (HFBR) to enhance neutron research in support of the DOE mission. Project scope includes reactor vessel replacement, construction of a Guide Hall and associated user instrumentation, design enhancements to improve HFBR performance, improve facility safety, reduce emissions and provide associated support facilities and utility services. The new Guide Hall will provide 5600 m^2 (60,000 sq. ft.) of experimental floor and support equipment space.

2. *Multiprogram Energy Laboratories / Facilities Support (MEL/FS) Program*

MEL/FS Program-supported projects have contributed to the renewal of the Laboratory's infrastructure, to the protection of the environment in the day-to-day conduct of operations, and to the continuing effort to provide safe, healthful work places at the Laboratory. Major permanent facilities constructed in the early 1960s need rehabilitation to meet current and future research program needs, and to address safety-related concerns. Utilities must be upgraded to protect the environment, to sustain present operations and to provide for future research programs. Facilities built in the 1940s needed modernization and renewal to provide an appropriate work-place environment. The following proposed projects are based on the anticipated / expected requirements which were developed, based on good business and facilities management practices.

Approved Projects

Fuel Transfer Facility (FY 1994) [In Construction]

A fuel transfer station will be constructed, including a concrete spill-containment basin and an enclosure of uninsulated metal siding on a structural steel frame totaling approximately 520 m^2 (5,600 ft^2). A 110 m^2 (1200 ft^2) pump house will be built adjacent to the fuel-transfer enclosure to comply with local and State codes for handling and storing fuel oil. Construction has begun and is expected to be completed by the end of 1996.

Applied Science Center - Phase I (FY 1995) [In Construction]

The Department of Applied Science (DAS) is a fragmented research department located in 27 buildings. Approximately 50% of the space occupied by the DAS is in World War II buildings, trailers, and wooden modular buildings. An existing permanent building (No. 815) was originally designed to eventually form the core of the Department. This building was constructed in 1961, was never expanded as planned, and is the newest of the buildings occupied by the Department.

It is intended that Building 815 will serve as a nucleus for the proposed Applied Science Center, and a series of additions in three phases would centralize the Department. The overall plan is to periodically construct additional modules to Building 815, until the consolidation is complete. This phase of approximately 1100 m^2 (12,000 ft^2) will consolidate the staff of the Environmental Chemistry Division, now housed in three widely separated locations. Construction has begun and is expected to be completed by April 1997.

Sanitary Wastewater System Upgrade - Phase II (FY 1995) [In Construction]

This second phase will continue to address the known deficiencies in the sewage collection and treatment system identified in the Sanitary Utility Site Development Plan. Construction of approximately 1,000 m (3,500 ft.) of pipe is complete. A Baseline Change Proposal (BCP) to modify the project scope addressing the need for additional upgrades at the Waste Treatment Plant has been submitted and is being reviewed by DOE. Replacement of additional pipe is proposed in the BCP to be deferred to the Sanitary System Mods - Phase III scheduled for FY99.

Loss Prevention Upgrades - Phase I (FY 1995) [In Construction]

As a result of the Tiger Team Assessment, it was determined that certain outdoor substations were deficient in their fire protection requirements. This project will relocate select transformers so they comply with Factory Mutual guidelines for fire protection, and also will establish fire walls and sprinkler protection in accordance with loss prevention criteria where such protection is lacking or inadequate. Over 90 existing substations will be upgraded. The initial construction package has been awarded, an additional construction package is out for bid, and the remainder of the work is in Title II design.

Hot Laboratory Renovations, Building 801 - Phase I (FY 1996) [In Design]

Building 801, the Hot Laboratory, is a forty-five year old facility housing elements of the Departments of Advanced Technology, Medical and Applied Science, as well as the Safety & Environmental Protection Division. The facilities and laboratories are inadequate for current uses and do not comply with environmental safety and health standards. The west side (the hot area) of the building will be renovated in this phase. Deficiencies in the ventilation system, radioactive waste system, security and fire alarm systems, electric power and lighting systems, and plumbing system will be corrected. The Project is currently in Title I investigation.

Materials Handling Warehouse - Phase I (FY 1998)
The basic stockroom functions presently are housed in four buildings, which are over 40-year-old, World War II temporary structures, and four trailers. In the first phase of the project, a new complex will be built which will require less space and will use modern warehousing technologies. It will reduce the current energy demands of the existing wood frame buildings. This project will address the poor conditions of the existing structures and will be the Laboratory's first effort to begin consolidating and relocating its warehousing and stockroom facilities into a more efficient, cost-effective operation. Savings will result from a reduction in operating personnel, implementation of more efficient stocking systems, and increases in building energy efficiency.

Inspections and analysis of structural members of the existing warehouses have revealed overstressed conditions in some structural members. The estimate to fully relieve these conditions is $0.5 M. The estimated payback for new construction considering all potential saving is approx. 10 years.

Electrical System Modifications - Phase I (FY 1998)
DOE and BNL's consulting engineers have emphasized the vulnerability of the electrical distribution systems and have recommended replacing deteriorating cables and ductbanks. This project covers the first phase of replacing existing old and deteriorating underground electric 13.8 kV cables and adding underground duct banks to support the cable systems. The existing cables, installed in the late 1940s, have outlived their useful life and will be replaced with new, solid dielectric shielded cables. New electric ductbanks and manholes for power and communication will support the new cable installations. This project will increase system reliability by reducing the number of unplanned outages to the Laboratory's research facilities and their duration. Direct repair costs associated with a typical 13.8 kV feeder failure are approx. $60 - $100 k and can cause program downtime of 16 to 48 hours.

Applied Science Center - Phase II (FY 1999)
Phase II represents a continuation of efforts to consolidate the Department of Applied Science. This addition to Building 815 will accommodate the Oceanographic and Atmospheric Sciences Division now housed in Buildings 318 and 194 (in part). Then DAS will no longer need Building 318, a high maintenance 55 year old building, which can then be demolished, This will result in a net reduction in maintenance costs for this associated space.

High Speed Fiber-Optic Infrastructure - Phase I (FY 2000)
The National Information Infrastructure is now a reality, 1994 saw thousands of commercial entities embrace the Internet as a medium for conducting business. The World Wide Web browser sparked a revolution that has brought with it a radical increase in demand for network bandwidth. Network providers are scrambling to increase their throughput and remove bottlenecks. The traffic on the Internet is increasing so rapidly that it cannot be predicted confidently from year to year and video teleconferencing over the Internet still is not widely used.

The Laboratory's infrastructure is, and has historically been, driven by short-sighted departmental centric projects that prioritized initial cost above all else. The resulting network that is very manpower-intensive and lacks an upgrade path to higher bandwidths. The only way to properly anticipate future requirements on the BNL network is through a consistent, long-term plan that does not require each department or division to allocate funds separately. This project will be a major step toward meeting the Laboratory's communications needs well into the future.

Electrical System Modifications - Phase II (FY 2001)
This project continues the progress made in Phase I by replacing old deteriorating underground electric 13.8 kV cables and adding supporting underground ductbank. The existing cables have outlived their useful life and will be replaced with new solid dielectric shielded cables. Based on condition assessment, other electrical equipment including transformers and switchgear will be replaced and/or retrofitted to extend their useful life.

Department of Advanced Technology Building - Phase I (FY 2001)
The Department currently occupies all or part of 10 buildings, most of which are either World War II era barracks, wooden modular buildings, or old permanent-type construction. This decentralized distribution of staff in old, ineffective buildings is demoralizing and decreases effective interchanges between staff members. Distances between buildings also make it inefficient for administration and management of the Department. Centralization of the staff would improve the working relationships, efficiency, and productivity of the DAT staff.

The proposed Phase I building would be located near existing permanent structures which house the major portion of experimental equipment/facilities used by the department. This phase would consolidate a significant part of the Department's administration, management, scientific, engineering and experimental staff, and result in a net reduction in maintenance costs for the associated space.

Boiler 5 Rehabilitation (FY 2002)
This project will cover a major overhaul of Boiler No. 5 to extend its useful service life. Boiler No. 5 is the Laboratory's largest boiler and is over 32 years old. A life extension overhaul is more cost efficient than complete replacement. The project will include non-destructive testing of all pressure components, needed retubing of the boiler, refractory replacement, repair of breeching and ductwork, and upgrades of the burners and controls. Cost offsets are estimated to be $3-3.5 M.

Central Chilled Water - Phase II (FY 2002)
The refrigeration capacity of the chilled water plant will be increased by an additional 13,125 kW (3,750 tons). The chilled water piping will be extended to connect seven additional buildings to its distribution network. Compressed air piping also will be extended in parallel with the chilled water distribution system. Benefits of this project include:

- Chiller system replacement cost offsets in the $7-10 M range.
- Annual energy and operations & maintenance savings of over $1.0 million/yr.
- Frees up mechanical and other buildings space for other uses.
- Increases system reliability and process temperature stability. Decreases noise and vibration in buildings.

Sanitary System Modifications - Phase III (FY 1999)

This phase of the overall project will address those deficiencies identified in the Sanitary System Master Plan, which were not dealt with in previous phases. This project will continue the Laboratory's program to replace and repair leaky sewer mains to protect Long Island's sole source aquifer. The sanitary system will be expanded to incorporate six building complexes at the RHIC site. Modifications to reduce dilution of the sewerage by non-sanitary discharges.

Storm/Cooling Water System Upgrades (FY 1999)

As required by the BNL SPDES permit, this upgrade will eliminate the cross connections between the storm and sanitary system. In addition, this project will modify building and programmatic cooling systems to reduce discharge of once-through non-contact cooling water to the sanitary system.

Halon System Replacement (FY 1999)

This project encompasses the replacement of Halon Systems due to environmental mandates (ozone depletion) - the Clean Air Act 1990. In recent years, the threat of Halon Fire Suppression Systems to the ozone layer has become evident. The Montreal Protocol and its amendments in 1993 demonstrate the need to phase-out halon systems. A project is needed to decommission and replace these systems with acceptable alternatives to maintain compliance with DOE's Fire Protection Standards. BNL has less than 100 halon systems. The replacement systems will include sprinkler systems, and very-early-warning detection (VESDA) or carbon dioxide systems (only for unoccupied areas). Halon fire extinguishers also will be replaced with suitable alternatives.

Hot Lab Renovation Building 801 - Phase II (FY 2000)

This project will renovate the east side of Building 801 (the Hot Lab "Cold Side"). Line Item remedial and renovation actions will include the abatement of asbestos and lead, adding office space, upgrading laboratories, and replacing the inadequate, deteriorated HVAC systems. The costs for a new building to replace the required space in Building 801 and demolition of Building 801 would be significantly higher than the proposed remediation and renovation work.

Life Safety Code Modifications - Phase I (FY 2000)

Sixteen buildings will be upgraded to comply with National Fire Protection "Life Safety Code" NFPA 101. This project will bring the facilities into compliance and make them safer for their occupants. Upgrades include modifications to building egress, stairwells, fire walls, sprinkler systems, emergency lighting, smoke detector systems, and other related requirements.

Fire Protection Improvements - Phase IV (FY 2001)

This project will put new fire protection sprinkler systems in ten facilities, and a very-early- warning smoke detection (VESDA) apparatus in the AGS tunnel. This system will increase the reliability of the system, thus reducing the risk to personnel and property.

Life Safety Code Modifications - Phase II (FY 2001)

This project continues the current Laboratory program for modifying Laboratory facilities to meet current NFPA Life Safety Code requirements.

Fire Protection Improvements - Phase V (FY 2002)

This project will implement improvements for fire protection in Buildings 88, 153, 170, 194, 197, 452, 459, 463, 480, 482, 490, 510, 555, 715 and 815, including automatic detection systems, and sprinkler protection systems.

Replace Site Fire Alarm System (FY 2002)

This project will replace BNL's Site Fire Alarm System (SFAS) and includes all building panels, primary, backup, developmental and three remote computer stations (remote alarm stations). Replacing these 40-year old building panels will improve compliance and reliability. The present site system was installed in 1988, but its technology will be obsolete by the year 2000.

Site Fire Alarm System Fiber-Optic Network (FY 2002)

This project will replace the use of telephone lines for the Site Fire Alarm System with fiber-optic communications so as to increase the system's reliability. The current system is hampered by the large number of connections, many of which are in underground manholes susceptible to environmental conditions.

3. In-House Energy Management

Chilled Water Storage Facility (FY 1993) [In Construction]]

The Laboratory's electric costs depend on the site's load factor. Producing and storing chilled water during off-peak electric hours reduces peak electric demand by approximately 3 MW. The site load factor will improve, realizing significant cost savings for the Laboratory. A chilled water storage system of 253,000 MJ (20,000 ton-hour) capacity will be installed at the Central Chilled Water Facility. Project completion is expected by August 1996.

	TEC	***** FUNDED ***** FY 1995	FY 1996	** BUDGETED ** FY 1997	FY 1998	********** PROPOSED ********** FY 1999	FY 2000	FY 2001	FY 2002
PROGRAM RELATED									
ACCELERATOR IMPROVEMENT PROJECTS (KA)		2.5	2.0	2.0	2.7	2.7	2.7	2.7	2.7
ACCELERATOR IMPROVEMENT PROJECTS (KB)		1.3	1.3	1.3	3.3	3.3	3.3	3.3	3.3
ACCELERATOR, REACTOR ADDITIONS & MODIFICATIONS (KC)		2.4	5.6	5.1	6.3	6.3	6.3	6.3	6.3
GENERAL PLANT PROJECTS (KA)		5.7	5.5	5.4	8.0	8.0	8.0	8.0	8.0
RELATIVISTIC HEAVY ION COLLIDER	486.9	70.0	65.0	65.0	59.4	15.7			
HOT LAB ADDITION FOR PET	3.7					0.5	3.2		
LIFE SCIENCES SUPPORT FACILITY	12.7					1.3	11.4		
NSLS DUV-FEL FACILITY	53.0						13.7	17.3	15.9
HFBR UPGRADE PROJECT (OUTYEAR FUNDING TBD)	182.0				15.0	TBD	TBD		
		81.9	79.4	78.8	94.7	37.8	48.6	37.6	36.2
VALIDATED CONSTRUCTION									
NSLS PHASE III UPGRADE	27.9					7.6	15.5	4.8	
		0.0	0.0	0.0	0.0	7.6	15.5	4.8	0.0
UNDER EVALUATION									
SPALLATION NEUTRON SOURCE									
MUON-MUON COLLIDER									
ENVIRONMENTAL RESTORATION AND WASTE MGMT									
WASTE MANAGEMENT FACILITIES	16.1	5.2							
FLOOR DRAIN MODIFICATIONS	2.1	0.1	(0.30)						
		5.3	(0.3)	0.0	0.0	0.0	0.0	0.0	0.0
ENERGY MANAGEMENT PROJECTS									
IN-HOUSE ENERGY MANAGEMENT		3.5							
		3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL PROGRAM LINE-ITEM PROJECTS		90.7	79.1	78.8	94.7	45.4	64.1	42.4	36.2

PROJECT

BROOKHAVEN NATIONAL LABORATORY
MAJOR CONSTRUCTION PROJECTS
($ IN MILLIONS IN BUDGET AUTHORITY)

			***** FUNDED *****		** BUDGETED **		********** PROPOSED **********			
		TEC	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
MEL/FS PROJECTS	**TYPE**									
FUNDED / BUDGETED										
ROOF REPLACEMENT I	2	2.0	0.1							
POTABLE WATER SYS. UPGRADE	1	5.3	1.9	(0.8)						
ENVIRONMENTAL IMPROVEMENTS	1	(2.4)	(0.2)							
FUEL TRANSFER FACILITY	5	3.6	2.5	0.4						
APPLIED SCIENCE BUILDING I	5	3.9	0.6	3.3						
SANITARY SYSTEM UPGRADE PHASE II	1	4.3	1.0	1.7	1.0	0.6				
LOSS PREVENTION UPGRADE I	1	7.7	0.6	2.5	4.6					
HOT LAB RENOVATION BLDG 801 PHASE	1	7.1		0.8	6.3					
			6.5	7.9	11.9	0.6	0.0	0.0	0.0	0.0
PROPOSED KG01										
MATERIAL HANDLING WAREHSE-PH1	5	6.9				0.9	6.0			
ELECTRICAL SYSTEM MODS. - PHASE I	3	5.7				1.2	4.5			
APPLIED SCIENCE CENTER PHASE II	5	5.0					0.8	4.2		
HIGH-SPEED F.O. INFRASTRUCT. PH. I	3	3.5						1.0	2.5	
ELECTRICAL SYSTEM MODS. PHASE II	3	4.0							1.5	2.5
DAT BUILDING PHASE I	5	5.0							0.5	4.4
BOILER 5 REHABILITATION	3	3.0								0.5
CENTRAL CHILLED WATER II	3	10.0								1.0
			0.0	0.0	0.0	2.1	11.3	5.2	4.5	8.4
PROPOSED KG02										
SANITARY SYSTEM UPGRADE PHASE III	1	3.5					0.5	3.0		
STORM & COOLING WATER UPGRADES	1	3.5					1.0	2.5		
HALON SYSTEM REPLACEMENT	1	3.0					0.5	2.5		
LIFE SAFETY CODE MODS. - PHASE I	1	4.0						0.5	2.5	1.0
HOT LAB RENOVATION B/801 PHASE II	1	6.0						0.6	4.0	1.4
FIRE PROTECTION PHASE IV	1	3.5							1.5	2.0
LIFE SAFETY CODE MODS PHASE II	1	4.0							1.5	2.5
FIRE PROTECTION PHASE V	1	4.0								0.5
REPLACE F/A SYSTEMS SITEWIDE	1	3.5								1.0
FIRE ALARM FIBER-OPTIC CABLES	1	5.0								1.0
			0.0	0.0	0.0	0.0	2.0	9.1	9.5	9.4
TOTAL GPF LINE-ITEM PROJECTS			6.5	7.9	11.9	2.7	13.3	14.3	14.0	17.8
TOTAL FUNDED CONSTRUCTION			97.2	87.3						
TOTAL BUDGETED CONSTRUCTION					90.7	97.4				
TOTAL PROPOSED CONSTRUCTION							58.7	78.4	56.4	54.0

MEL/FS PROJECT TYPES
1. ES&H SUPPORT
2. BUILDING REHAB AND UPGRADE
3. UTILITY SYSTEM REHAB AND UPGRADE
4. ROADS AND OSF REHAB AND UPGRADE
5. NEW BUILDING

B. INFORMATION RESOURCE MANAGEMENT

1. Goals and Objectives

Brookhaven National Laboratory regards Information Resource Management as extremely important to the effectiveness of our scientific programmatic performance, as well as the efficiency and cost-effectiveness of our administrative functions. Information facilities and resources are widely distributed at the Laboratory, tied together with a robust site-wide network that is facing escalating pressures for expansion and improvement. The Laboratory strives to balance the need for distributed computing with that of central administration.

2. Current Situation

The Information Resource Management (IRM) organization structure includes the Computing and Communications Division (CCD), the Business Information Systems (BIS) section of the Financial Services Division (FSD), and the Information Services Division (ISD). Various specialized data and information centers are also considered an integral part of Information Resources Management. These include the National Nuclear Data Center (NNDC), Protein Data Bank, and the HEP/NP (High-Energy Physics/ Nuclear Physics) Consortium, consisting of the powerful computer services of the Physics Department, Relativistic Heavy Ion Collider (RHIC), and the On-Line Data Facility (OLDF). All of these organizations manage information resources utilizing computer-based technology.

Management advisory committees are established for the Computing and Communications Division, the Business Information Systems section of FSD, and the Information Services Division. Comprised of a mix of scientific and administrative personnel, these committees advise Laboratory management on policies and operational procedures relating to information management.

Responsibility for scientific and technical computing resides in the Computing and Communications Division, as well as the variety of systems centered around data acquisition within the different scientific research programs. A significant number of computers are also involved in a variety of control tasks at the various experimental facilities. The Information Services Division plays a significant role in providing access to databases both on site and at other institutions throughout the world.

CCD provides infrastructure support in many areas of computing and communications, and is organized along the following *service* lines: Hardware Support (installation and maintenance), Systems Support (BNL Computing Facility, software and licensing support, remote facilities management), Network Support (Local Area Networks and access to the Internet and other national and international networks), Telecommunications, the Personal Computer Resource Center, and the Advanced Technology and Planning Group.

Administrative systems support is largely provided by the Business Information Systems section of the Financial Services Division. This new division was formed in February 1996 combining the Management Information Systems Division (MIS), the Fiscal Division and the Financial Management and Accounting Project. This restructuring was done in order to help facilitate the close coordination and cooperation required as BNL embarks on a replacement of its entire accounting system. The BIS section of the new division provides systems development and programming resources, centralized processing, security, application training and archiving for major business systems that include Fiscal, Budget, Purchasing, Inventory, Payroll and Human Resources.

The Information Services Division was formed by merging the Technical Information Division and Photography and Graphic Arts in February 1995. ISD's areas of responsibility include the Research Library,

Records Management, Publications, Video, Photography, Duplication, and Database Support. Databases are developed and supported using Oracle and BASISPlus. A third product, ARC/Info is a Geographic Information System (GIS) for databases requiring spatial information. The BNL World Wide Web (WWW), maintained by the Information Services Division, establishes hyperlinks to all known Web Home pages at the Laboratory. In addition, off-site resources are consolidated under BNL Scientific and Technical Information. ISD is also responsible for on-line publishing at the Laboratory and makes centrally located high speed systems available over the network. Imaging devices for typesetting and color imaging are available. CD-ROM storage of documents and images and digital photography services are also now available. Satellite receiving dishes provide live lecture and interactive information broadcasts that are recorded for later viewing.

3. Strategies

Major emphasis in the Computing and Communications Division has been given to the continued expansion of high speed networking facilities, especially interconnection of Local Area Networks (LANs) in various facilities to the Lab FDDI backbone. Work on local and regional Asynchronous Transfer Mode (ATM) networking, which is widely regarded as the "next generation" in network architecture is in progress. A three dimensional graphics "CAVE" facility has been developed for applications requiring advanced visualization. The growing demand for electronic multi-media document management, and spatial data in a Geographic Information System (GIS) is creating a strong demand for increased access and high bandwidth network facilities.

This year ISD's efforts included the development of a Field Work Proposal (FWP) database and electronic submission of FWP's and related Budget Office data to DOE's Office of Scientific and Technical Information. ISD continues to provide service to the National Synchrotron Light Source (NSLS) for electronic submission of all abstracts for their annual Activity Report and making the abstracts available on the World Wide Web.

Another database initiative is ISD's development of the Laboratory's centralized training database, the BNL Training Management System (BTMS), under the direction of the Central Training Office in the Human Resources Division. Phase I development (centralization of training records) will be completed by fiscal year end. The BTMS will provide data essential assessing BNL's progress on a contractual performance measure.

ISD was awarded the Superconducting Super Collider Library collection. A major ISD initiative is the full integration of the SSC collection with the BNL collection. Duplicative or unneeded items will be offered to other national laboratories. This acquisition will increase the Laboratory's book collection by approximately 20,000 volumes.

ISD is implementing an on-line job estimating, tracking and invoicing system for Photography and Graphic Arts services. Copy Service, Printing, Graphic Design, Photography and Video services will be brought to full recharge this year using this software tool.

4. Resources and Initiatives

In FY95 BNL spent approximately three million dollars on computing hardware, of which the majority was spent on microcomputers (PCS and MACs) and the remainder on workstations (including major servers). In keeping with the industry-wide trend, no main frames were acquired. However, the support of an increasing number of distributed machines is a major challenge which has prompted the development of remote software installation and upgrade techniques. Along the same lines, the support of an ever expanding network has occasioned the formation of a Network Operations Center (NOC) and the extensive use of monitoring tools. Again, the distributed nature of Information Resource Management at the Laboratory drives the initiative to analyze and improve the existing Laboratory network structure.

Major initiatives are as follows:

a) Replacement of our 15 year old telephone switching system by a modern one with an increased focus on digital data transmission was completed in March 1996.

b) ISD has acquired state-of-the-art equipment for digital photography. Full digital photography services are now available.

c) The Computing and Communications Division is actively involved in a number of initiatives aimed at exploring the use of Asynchronous Transfer Mode (ATM) technology and 3D Visualization to meet future high speed networking and graphic requirements. BNL is one of a number of national laboratories engaged in studying the use of ATM and 3D video to create a future multi-site "collaboratory" environment.

d) ISD has acquired equipment and indexing software for mastering of CD-ROMs. This service will be offered by Photography and Graphic Arts to provide for CD-ROM storage of documents and images.

e) ISD continues to offer electronic publishing services including the creating of multi-media and Standard Generalized Markup Language (SGML) documents.

f) The processing and storage requirements for the data to be generated by the Relativistic Heavy Ion Collider (RHIC) when it comes on line will exceed anything done before along these lines at BNL. Therefore, the use of parallel computers is being investigated and an 8-node Scalable POWERparallel (SP1) machine has been purchased from IBM. The timely build up of RHIC computing resources is likely to be the major computing initiative at BNL for the next few years.

g) The Financial Services Division received a mandate from the Cost Control Committee and the Laboratory directorate to replace BNL's aging management and accounting system with an "off-the-shelf" suite of financial packages. To this end an RFP was issued and PeopleSoft was selected as the vendor to replace all of BNL's existing systems with the exception of Human Resources and Payroll. It is expected that this project, with the involvement of a 3rd party integrator, will take approximately two (2) years to complete.

h) A review of BNL's Human Resources and Payroll systems is underway in order to determine 1) the adequacy of the current system and the feasibility of maintaining it; 2) the possibility of outsourcing either or both of the systems and 3) replacing the two systems with modules available from the financials vendor, PeopleSoft.

IX. RESOURCE PROJECTIONS

This section contains the resource projections associated with the fulfillment of the program plans embodied in the preceding text. In the following Tables, costs for FY97 and FY98 were escalated by the following factors:

	FY 1997	FY 1998
OPERATING	3.8%	4.1%
CAPITAL EQUIPMENT	2.7%	2.7%
CONSTRUCTION	3.1%	3.3%

FY99 through FY02 projections in constant FY98 dollars.
Also, Budget Authority (BA) projections for Operating Costs do not include any Goods and Services on Order (GSO) balances.

PROCUREMENTS, SUBCONTRACTS, AND TRANSFERS
($ in Millions - B/A)

Fiscal Years	1995	1996	1997	1998	1999	2000	2001	2002
TRANSFERS[1]	7.3	7.0	5.0	3.0	3.0	3.0	3.0	3.0
UNIVERSITY Subcontracts	7.2	7.0	5.0	4.0	4.0	4.0	4.0	4.0
ALL OTHER Procurements	178.5	192.1	152.6	150.2	153.5	157.9	162.3	166.9
TOTAL	193.0	206.1	162.6	157.2	160.5	164.9	169.3	173.9

[1] The funds in this area were expended for RHIC project research, waste management, fuel elements and small research studies distributed among national laboratories.

SMALL DISADVANTAGED BUSINESS PROGRAM

The Laboratory has made a strong commitment to increase the opportunities for small disadvantaged businesses (SDBs) to respond to our procurement needs. In so doing, it has established business practices and procedures which maximize practicable opportunities for SDBs to participate in AUI's performance of the prime contract. The goal of 5% of total procurement dollars has been established for FY96.

Summary

The Division of Contracts and Procurement (DCP) has developed an active SDB program which consists of the following main elements:

- Practical Application in Procurement
- Buyer Incentive Program
- SDB Development Outreach

The Manager of DCP has overall responsibility for implementation of the program. A Small and Small Disadvantaged Business Liaison Officer has been appointed to manage the program on a day-to-day basis.

Practical Application in Procurement

The Laboratory has designated categories of commodities which are set aside for small and small disadvantaged business. In addition, DCP has established a source directory of SDBs to facilitate location and identification of these businesses. Workshops, seminars and other less formal means are used to educate the buyers in their responsibilities with respect to SDB participation. Individual guidance is provided as required.

Buyer Incentive Program

Each buyer is expected to individually meet the Laboratory's goal of 5%. Buyers who meet these goals are recognized quarterly, and those whose performance with respect to SDB participation during the year is exemplary are recognized in the "Buyer of the Year" program.

SDB Development Outreach Program

The Liaison Officer and designated buyers participate in SDB trade fairs and conferences. SDBs which are interested in doing business with the Laboratory are invited to meet with the Liaison Officer and appropriate buyers to present their qualifications and learn about BNL's requirements. The Liaison Officer provides guidance to SDBs as necessary.

SDB PROGRAM RESULTS/PROJECTIONS

	Total Procurement $	% Goal	$ to SDB's	$ Achieved*	
FY 1994	157,910,738.	5%	7,359,183.		5.4%
FY 1995 (Projected)	193,045,438.	5%	13,571,727.		8.0%
FY 1996 (Projected)	206,100,000.	5%	10,305,000.		
FY 1997	162,600,000.	5%	8,130,000.		

* SBD Percentage is calculated on Small and Large Business combination only. All procurements to Governments, GOCOs, Foreign and Institutions have been eliminated.

DEPARTMENT OF ENERGY PROGRAMS

DIRECTOR, OFFICE OF ENERGY RESEARCH

AT-15 DEVELOPMENT & TECHNOLOGY				
OPERATING	0.1	0.1	0.2	0.2
TOTAL COST	0.1	0.1	0.2	0.2
DIRECT PERSONNEL	1	-	1	1
KA-01 PHYSICS RESEARCH				
OPERATING	8.0	7.8	9.6	9.6
CAPITAL EQUIPMENT	1.2	0.9	1.9	11.7
TOTAL COST	9.2	8.7	11.5	21.3
DIRECT PERSONNEL	54	51	57	57
KA-02 FACILITY OPERATIONS				
OPERATING +	44.9	44.1	54.4	53.7
CHANGES IN INVENTORIES	0.0	0.0	0.9	1.1
CAPITAL EQUIPMENT	3.7	3.6	2.9	2.8
CONSTRUCTION (AIP)	2.5	2.0	2.0	2.7
TOTAL COST	51.1	49.7	60.2	60.3
DIRECT PERSONNEL	229	236	244	248
KA-03 HIGH ENERGY TECHNOLOGY				
OPERATING	6.3	7.3	9.2	9.5
CAPITAL EQUIPMENT	0.2	0.2	0.4	0.2
TOTAL COST	6.5	7.5	9.6	9.7
DIRECT PERSONNEL	41	37	47	47
KA HIGH ENERGY PHYSICS				
OPERATING +	59.2	59.2	73.2	72.8
CHANGES IN INVENTORIES	0.0	0.0	0.9	1.1
CAPITAL EQUIPMENT	5.1	4.7	5.2	14.7
CONSTRUCTION (AIP)	2.5	2.0	2.0	2.7
TOTAL COST	66.8	65.9	81.3	91.3
DIRECT PERSONNEL	324	324	348	352

\+ FY1999 AND FY2000 ASSUMES 30 WK. FAST EXTRACTED BEAM PROGRAM. A 20 WK. SLOW BEAM P

* ESCALATION FACTORS: FY1997 AND 1998 OPERATING COSTS AT 3.8% AND 4.1% RESPECTIVELY.

** CONSTANT FY1998 DOLLARS

KB-01 MEDIUM ENERGY PHYSICS				
OPERATING	2.4	2.4	2.5	2.5
CAPITAL EQUIPMENT	-	0.6	1.0	0.7
TOTAL COST	2.4	3.0	3.5	3.2
DIRECT PERSONNEL	18	15	15	15
KB-02 HEAVY ION PHYSICS				
RESEARCH				
PHYSICS	5.7	6.1	6.9	7.3
RHIC R&D	3.6	-	-	-
TOTAL RESEARCH	9.3	6.1	6.9	7.3
FACILITY OPERATIONS				
AGS/TVDG OPERATIONS	6.5	7.4	8.2	8.7
RHIC PRE-OPS/ INVENTORY	2.2	8.5	11.0	19.0
RHIC OPERATIONS	-	-	-	-
TOTAL FACILITY OPERATIONS	8.7	15.9	19.2	27.7
TOTAL OPERATING	18.0	22.0	26.1	35.0
CAPITAL-AEE	0.7	2.9	6.2	8.5
CAPITAL-GENERAL	3.1	2.1	2.3	2.3
CAPITAL-NEW EXPERIMENTS	-	-	-	-
TOTAL CAPITAL	3.8	5.0	8.5	10.8
CONSTRUCTION (AIP)	1.3	1.3	1.3	3.3
CONSTRUCTION (RHIC) (a)	70.0	65.0	65.0	59.4
TOTAL CONSTRUCTION	71.3	66.3	66.3	62.7
TOTAL COST	93.1	93.3	100.9	108.5
DIRECT PERSONNEL	480	469	450	430
KB-03 NUCLEAR THEORY				
OPERATING	1.2	1.1	1.1	1.2
DIRECT PERSONNEL	6	6	6	7
KB-04 LOW ENERGY PHYSICS				
OPERATING	3.1	2.7	3.2	3.7
CAPITAL EQUIPMENT	-	-	0.1	0.1
TOTAL COST	3.1	2.7	3.3	3.8
DIRECT PERSONNEL	17	16	15	15
KB NUCLEAR PHYSICS				
OPERATING	24.7	28.2	32.9	42.4
CAPITAL EQUIPMENT	3.8	5.6	9.6	11.6
CONSTRUCTION (AIP)	1.3	1.3	1.3	3.3
CONSTRUCTION (RHIC) (a)	70.0	65.0	65.0	59.4
TOTAL CONSTRUCTION	71.3	66.3	66.3	62.7
TOTAL COST	99.8	100.1	108.8	116.7
DIRECT PERSONNEL	521	506	486	467

(a) FUNDED

* ESCALATION FACTORS: FY1997 AND 1998 OPERATING COSTS AT 3.8% AND 4.1% RESPECTIVELY.
** CONSTANT FY1998 DOLLARS

KC-02 MATERIALS SCIENCES				
OPERATING (RESEARCH)	10.4	10.9	14.8	14.6
NSLS OPERATIONS	16.3	18.2	21.7	22.4
HFBR OPERATIONS	20.8	22.4	24.5	25.4
TOTAL OPERATING	47.5	51.5	61.0	62.4
CHANGES IN INVENTORIES	0.0	0.0	0.0	1.9
CAPITAL EQUIPMENT	1.3	4.5	4.1	4.1
CONSTRUCTION				
ARAM	2.4	5.6	5.1	6.3
HFBR FACILITIES UPGRADE (c1)				15.0
NSLS PHASE-III UPGRADE (b)				
TOTAL CONSTRUCTION	2.4	5.6	5.1	21.3
TOTAL COST	51.2	61.6	70.2	89.7
DIRECT PERSONNEL	292	288	308	314
KC-03 CHEMICAL SCIENCES				
OPERATING (RESEARCH)	9.8	9.6	11.1	11.3
NSLS OPERATIONS	7.1	7.9	9.3	9.6
TOTAL OPERATING	16.9	17.5	20.4	20.9
CHANGES IN INVENTORIES	0.0	0.0	0.2	0.0
CONSTRUCTION				
NSLS DUV-FEL FACILITY (c)				
CAPITAL EQUIPMENT	2.3	1.9	3.2	4.0
TOTAL COST	19.2	19.4	23.8	24.9
DIRECT PERSONNEL	112	94	100	104
KC-04 ENGINEERING AND GEOSCIENCES				
OPERATING	0.5	0.5	0.5	0.5
CAPITAL EQUIPMENT	0.1	0.1	0.1	0.1
TOTAL COST	0.6	0.6	0.6	0.6
DIRECT PERSONNEL	1	2	3	3
KC-06 ENERGY BIOSCIENCES				
OPERATING	1.0	1.1	1.3	1.3
CAPITAL EQUIPMENT	0.1	0.1	0.2	0.2
TOTAL COST	1.1	1.2	1.5	1.5
DIRECT PERSONNEL	6	7	8	8
KC-07 APPLIED MATHEMATICAL SCIENCES				
OPERATING	0.9	0.8	1.0	1.0
CAPITAL EQUIPMENT	-	-	-	-
TOTAL COST	0.9	0.8	1.0	1.0
DIRECT PERSONNEL	4	5	3	4

(b) VALIDATED
(c) PROPOSED (c1) BUDGETED/OUT-YEAR FUNDING TO BE DETERMINED

* ESCALATION FACTORS: FY1997 AND 1998 OPERATING COSTS AT 3.8% AND 4.1% RESPECTIVELY.
** CONSTANT FY1998 DOLLARS

KC BASIC ENERGY SCIENCES				
OPERATING (RESEARCH)	22.6	22.9	28.7	28.7
NSLS OPERATIONS	23.4	26.1	31.0	32.0
HFBR OPERATIONS	20.8	22.4	24.5	25.4
TOTAL OPERATING	66.8	71.4	84.2	86.1
CHANGES IN INVENTORIES	0.0	0.0	0.2	1.9
CAPITAL EQUIPMENT	3.8	6.6	7.6	8.4
CONSTRUCTION				
ARAM	2.4	5.6	5.1	6.3
HFBR FACILITIES UPGRADE (c1)	0.0	0.0	0.0	15.0
NSLS PHASE-III UPGRADE (b)	0.0	0.0	0.0	0.0
NSLS DUV-FEL FACILITY (c)	0.0	0.0	0.0	0.0
TOTAL CONSTRUCTION	2.4	5.6	5.1	21.3
TOTAL COST	73.0	83.6	97.1	117.7
DIRECT PERSONNEL	415	396	422	433
KD ENERGY RESEARCH ANALYSIS				
OPERATING	0.1	-	0.1	0.1
DIRECT PERSONNEL	1	1	1	1
KG MULTIPROGRAM ENERGY LABORATORIES				
OPERATING	1.1	1.2	1.2	1.2
CAPITAL EQUIPMENT	0.1	-	-	-
CONSTRUCTION	6.4	7.9	11.9	2.7
TOTAL COST	7.6	9.1	13.1	3.9
DIRECT PERSONNEL	6	8	6	6
KP BIOLOGICAL & ENVIRONMENTAL RESEARCH				
OPERATING	27.1	26.6	37.3	38.0
CAPITAL EQUIPMENT	3.9	0.9	3.9	2.9
CONSTRUCTION				
HOT LAB ADDITION FOR PET (c)	-	-	-	-
LIFE SCIENCES SUPPORT FACILITY (c)	-	-	-	-
TOTAL CONSTRUCTION	0.0	0.0	0.0	0.0
TOTAL COST	31.0	27.5	41.2	40.9
DIRECT PERSONNEL	144	142	176	182
KU ER LABORATORY TECHNOLOGY TRANSFER				
OPERATING	7.6	2.1	4.4	5.4
DIRECT PERSONNEL	27	32	20	24
TOTALS-ENERGY RESEARCH				
TOTAL OPERATING	186.7	188.8	233.5	246.2
CHANGE IN INVENTORIES	0.0	0.0	1.1	3.0
CAPITAL EQUIPMENT	16.7	17.8	26.3	37.6
CONSTRUCTION	82.6	81.8	85.3	89.4
TOTAL COST	**286.0**	**288.4**	**346.2**	**376.2**
DIRECT PERSONNEL	1439	1409	1460	1466

(b) VALIDATED

(c) PROPOSED (c1) BUDGETED/OUT-YEAR FUNDING TO BE DETERMINED

* ESCALATION FACTORS: FY1997 AND 1998 OPERATING COSTS AT 3.8% AND 4.1% RESPECTIVELY.

** CONSTANT FY1998 DOLLARS

A/S, CONSERVATION & RENEWABLE ENERGY				
AK-06 SYSTEMS TECHNOLOGY				
OPERATING	0.6	0.4	0.4	0.4
DIRECT PERSONNEL	2	2	2	2
AM GEOTHERMAL				
OPERATING	0.2	1.3	1.5	1.5
CAPITAL EQUIPMENT	-	0.1	0.1	0.2
TOTAL COST	0.2	1.4	1.6	1.7
DIRECT PERSONNEL	1	9	10	10
EB SOLAR ENERGY				
OPERATING	0.4	0.3	0.3	0.4
DIRECT PERSONNEL	2	2	2	2
EC BUILDINGS AND COMMUNITY SYSTEMS				
OPERATING	1.4	1.4	0.9	1.4
CAPITAL EQUIPMENT	-	-	0.1	-
TOTAL COST	1.4	1.4	1.0	1.4
DIRECT PERSONNEL	8	7	8	8
EE TRANSPORTATION				
OPERATING	0.6	1.5	1.2	1.1
TOTAL COST				
DIRECT PERSONNEL	2	4	6	6
TOTALS-CONSERVATION & RENEWABLE ENERGY				
OPERATING	3.2	4.9	4.3	4.8
CAPITAL EQUIPMENT	0.0	0.1	0.2	0.2
TOTAL COST	**3.2**	**5.0**	**4.5**	**5.0**
DIRECT PERSONNEL	15	24	28	28
A/S, ENVIRONMENT,SAFETY & HEALTH				
HA-01 ENVIRONMENT,SAFETY AND HEALTH				
OPERATING	1.6	1.3	2.6	2.1
CAPITAL EQUIPMENT	-	-	0.4	-
TOTAL COST	1.6	1.3	3.0	2.1
DIRECT PERSONNEL	9	5	9	8
HP NUCLEAR SAFETY POLICY				
OPERATING	0.9	0.6	0.9	0.9
DIRECT PERSONNEL	3	2	2	2
HR EPIDEMIOLOGIC ACTIVITIES				
OPERATING	1.8	1.8	1.8	1.8
CAPITAL EQUIPMENT	0.2	0.1	0.2	-
TOTAL COST	2.0	1.9	2.0	1.8
DIRECT PERSONNEL	9	10	9	9

* ESCALATION FACTORS: FY1997 AND 1998 OPERATING COSTS AT 3.8% AND 4.1% RESPECTIVELY.
** CONSTANT FY1998 DOLLARS

NS NUCLEAR SAFETY OVERSIGHT				
OPERATING	0.4	0.7	0.2	0.2
DIRECT PERSONNEL	2	3	1	1
TOTALS-ENVIRONMENT, SAFETY, AND HEALTH				
OPERATING	4.7	4.4	5.5	5.0
CAPITAL EQUIPMENT	0.2	0.1	0.6	0.0
TOTAL COST	**4.9**	**4.5**	**6.1**	**5.0**
DIRECT PERSONNEL	23	20	21	20
A/S, DEFENSE PROGRAMS				
GB WEAPONS ACTIVITIES				
OPERATING	1.9	-	0.9	0.9
CAPITAL EQUIPMENT	-	-	-	-
TOTAL COST	1.9	0.0	0.9	0.9
DIRECT PERSONNEL	10	-	1	1
GC VERIFICATION RESEARCH AND DEVELOPMENT				
OPERATING	4.4	4.5	8.0	8.1
CAPITAL EQUIPMENT	0.7	0.3	1.7	1.9
TOTAL COST	5.1	4.8	9.7	10.0
DIRECT PERSONNEL	21	16	16	18
GD NUCLEAR SAFEGUARDS & SECURITY				
OPERATING	0.5	0.6	1.8	1.5
CAPITAL EQUIPMENT	-	0.1	-	-
TOTAL COST	0.5	0.7	1.8	1.5
DIRECT PERSONNEL	3	3	5	5
DP OTHER WEAPONS ACTIVITIES				
OPERATING	3.2	6.2	6.2	8.3
DIRECT PERSONNEL	13	21	23	24
GJ ARMS CONTROL AND NONPROLIFERATION				
OPERATING	2.1	8.5	8.4	7.6
CAPITAL EQUIPMENT	-	0.1	0.1	0.1
TOTAL COST	2.1	8.6	8.5	7.7
DIRECT PERSONNEL	10	10	17	17
ND EMERGENCY MANAGEMENT				
OPERATING	-	0.2	0.2	0.2
DIRECT PERSONNEL	-	2	2	2
TOTALS-DEFENSE PROGRAMS				
OPERATING	12.1	20.0	25.5	26.6
CAPITAL EQUIPMENT	0.7	0.5	1.8	2.0
TOTAL COST	**12.8**	**20.5**	**27.3**	**28.6**
DIRECT PERSONNEL	57	52	64	67

* ESCALATION FACTORS: FY1997 AND 1998 OPERATING COSTS AT 3.8% AND 4.1% RESPECTIVELY.

** CONSTANT FY1998 DOLLARS

A/S ENVIRONMNTL. RESTORATION AND WASTE MGMT.				
EW/EX ENVIRONMNTL. RESTORATION AND WASTE MGMT.				
OPERATING	25.0	33.3	32.1	30.6
CAPITAL EQUIPMENT	0.2	0.1	0.1	0.1
CONSTRUCTION	5.3	(0.3)	-	-
TOTAL COST	**30.5**	**33.1**	**32.2**	**30.7**
DIRECT PERSONNEL	72	78	69	70
A/S, FOSSIL ENERGY				
AA COAL				
OPERATING	0.3	0.2	0.3	0.4
DIRECT PERSONNEL	1	1	1	1
AC PETROLEUM				
OPERATING	1.0	1.0	1.0	1.0
DIRECT PERSONNEL	5	4	4	4
AZ CLEAN COAL				
OPERATING	0.2	0.2	0.3	0.3
DIRECT PERSONNEL	2	1	2	2
TOTALS-FOSSIL ENERGY				
OPERATING	**1.5**	**1.4**	**1.6**	**1.7**
DIRECT PERSONNEL	8	6	7	7
OFFICE OF NUCLEAR ENERGY				
AF NUCLEAR ENERGY R&D				
OPERATING	0.1	-	-	-
DIRECT PERSONNEL	1	-	-	-
CD URANIUM PROGRAMS				
OPERATING	0.3	0.1	-	-
DIRECT PERSONNEL	1	-	-	-
ST ISOTOPE PRODUCTION AND DISTRIBUTION PROGRAM				
OPERATING	0.8	1.2	1.0	1.0
CAPITAL EQUIPMENT	0.2	0.3	0.1	0.1
TOTAL COST	1.0	1.5	1.1	1.1
DIRECT PERSONNEL	3	4	3	3
TOTALS-OFFICE OF NUCLEAR ENERGY				
OPERATING	1.2	1.3	1.0	1.0
CAPITAL EQUIPMENT	0.2	0.3	0.1	0.1
TOTAL COST	**1.4**	**1.6**	**1.1**	**1.1**
DIRECT PERSONNEL	5	4	3	3
OFFICE OF SCIENTIFIC EDUCATION/TECNICAL INFO.				
KT UNIVERSITY AND SCIENCE EDUCATION				
OPERATING	**2.0**	**0.7**	**1.2**	**1.5**
DIRECT PERSONNEL	7	6	6	6

* ESCALATION FACTORS: FY1997 AND 1998 OPERATING COSTS AT 3.8% AND 4.1% RESPECTIVELY.
** CONSTANT FY1998 DOLLARS

OFFICE OF POLICY, PLANNING, AND ANALYSIS				
PE POLICY, ANALYSIS AND SYSTEMS STUDIES				
OPERATING	0.2	0.1	0.1	0.1
CAPITAL EQUIPMENT	-	-	-	-
TOTAL COST	**0.2**	**0.1**	**0.1**	**0.1**
DIRECT PERSONNEL	1	1	1	1
OFFICE OF FINANCIAL MANAGEMENT AND CONTROLLER				
WB IN-HOUSE ENERGY MANAGEMENT				
OPERATING	**0.3**	-	-	-
DIRECT PERSONNEL	-	-	-	-
WORK FOR OTHERS PROGRAMS				
NUCLEAR REGULATORY COMMISSION				
NUCLEAR REACTOR REGULATION (d)				
OPERATING	2.8	0.9	1.0	1.0
DIRECT PERSONNEL	16	7	8	8
NUCLEAR MATERIAL SAFETY & SAFEGUARDS				
OPERATING	0.1	0.1	0.1	0.1
DIRECT PERSONNEL	1	1	1	1
NUCLEAR REGULATORY RESEARCH				
OPERATING	12.2	8.5	7.5	7.5
CAPITAL	0.1	-	0.1	0.1
CONSTRUCTION	-	-	-	-
TOTAL COST	12.3	8.5	7.6	7.6
DIRECT PERSONNEL	56	47	44	43
TOTALS-NUCLEAR REGULATORY COMMISSION				
OPERATING	15.1	9.5	8.6	8.6
CAPITAL	0.1	0.0	0.1	0.1
CONSTRUCTION	0.0	0.0	0.0	0.0
TOTAL COST	**15.2**	**9.5**	**8.7**	**8.7**
DIRECT PERSONNEL	73	55	53	52
DEPARTMENT OF STATE				
OPERATING	**3.9**	**6.7**	**8.4**	**8.4**
DIRECT PERSONNEL	8	14	16	16

(d) OFFICE OF ADMINISTRATION AND RESOURCE MANAGEMENT WORK REFLECTED IN NUCLEAR REA

* ESCALATION FACTORS: FY1997 AND 1998 OPERATING COSTS AT 3.8% AND 4.1% RESPECTIVELY.

** CONSTANT FY1998 DOLLARS

SUPPORT FROM OTHERS PROGRAMS				
DEPARTMENT OF DEFENSE				
OPERATING	14.0	2.9	2.5	2.1
CAPITAL	-	0.1	0.1	0.1
TOTAL COST	**14.0**	**3.0**	**2.6**	**2.2**
DIRECT PERSONNEL	22	16	12	12
NAT'L AERONAUTICS AND SPACE ADMINISTRATION				
OPERATING	**1.2**	**0.4**	**1.0**	**1.0**
DIRECT PERSONNEL	3	4	3	3
DEPARTMENT OF HEALTH & HUMAN SERVICES				
OPERATING	**4.1**	**4.3**	**4.2**	**3.8**
DIRECT PERSONNEL	16	16	15	14
NATIONAL SCIENCE FOUNDATION				
OPERATING	**1.5**	**1.3**	**1.6**	**1.6**
DIRECT PERSONNEL	5	4	5	5
ENVIRONMENTAL PROTECTION AGENCY				
OPERATING	**3.2**	**1.2**	**1.2**	**0.5**
DIRECT PERSONNEL	7	5	5	1
OTHER FEDERAL AGENCIES				
OPERATING	1.7	0.4	0.8	0.9
CAPITAL	0.4	0.1	-	-
TOTAL COST	**2.1**	**0.5**	**0.8**	**0.9**
DIRECT PERSONNEL	12	7	4	4
OTHER DOE LABS				
OPERATING	18.2	17.4	9.5	8.7
CAPITAL	-	0.1	-	-
TOTAL COST	**18.2**	**17.5**	**9.5**	**8.7**
DIRECT PERSONNEL	40	34	30	30
ALL OTHERS				
OPERATING	3.1	2.1	4.5	5.0
CAPITAL	-	-	-	-
TOTAL COST	**3.1**	**2.1**	**4.5**	**5.0**
DIRECT PERSONNEL	15	34	46	51

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** CONSTANT FY1998 DOLLARS